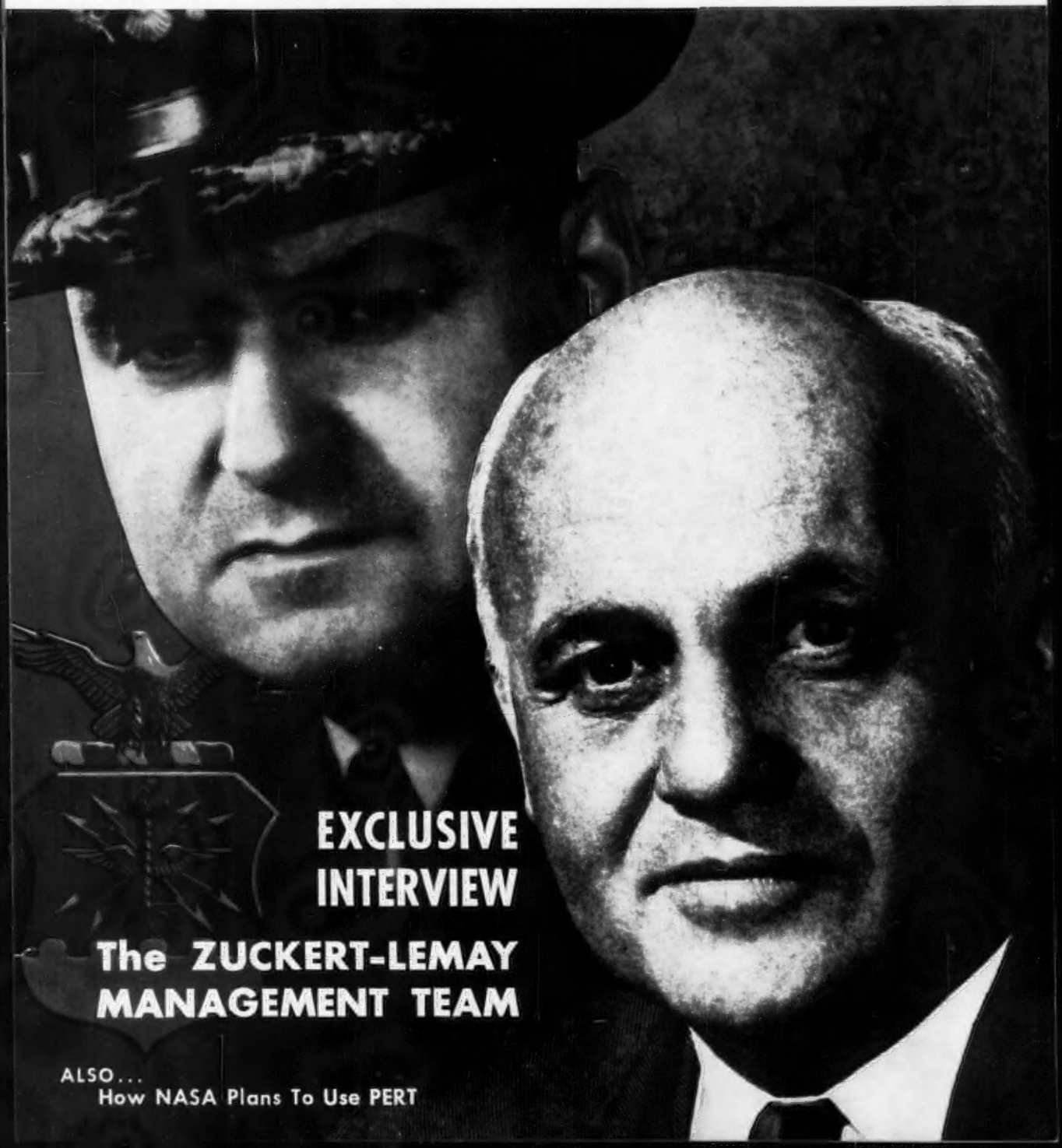
AEROSPACE MANAGEMENT

FOR TECHNICAL DECISION-MAKING AND LONG-RANGE PLANNING

A Chilton Publication

DECEMBER, 1961

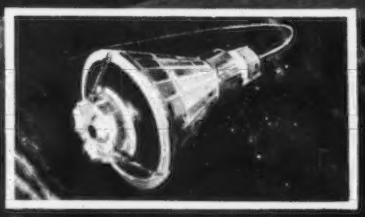


EXCLUSIVE INTERVIEW

The ZUCKERT-LEMAY MANAGEMENT TEAM

ALSO...
How NASA Plans To Use PERT

ELECTRONICS



in astronautics

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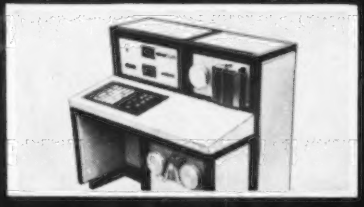

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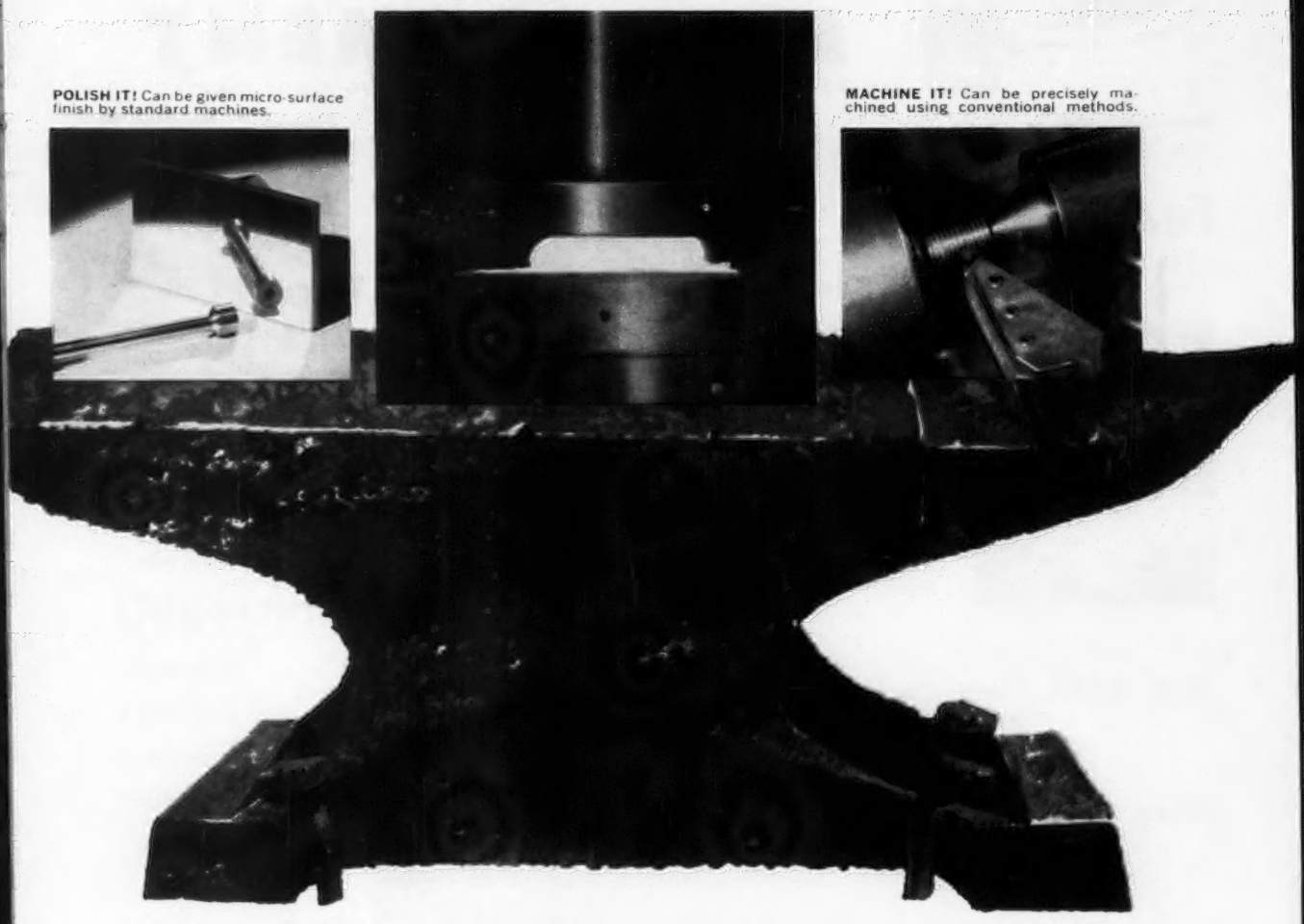

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AEROSPACE MANAGEMENT

FOR TECHNICAL DECISION-MAKING AND LONG-RANGE PLANNING

December, 1961 Volume 4, Number 12

Features

THE COVER STORY . . . **The Zuckert-LeMay Management Team . . . 20**

In the E-ring of the Pentagon, fourth floor, room 871, sits the man who is technically at the top of the management heap in Air Force. But, Eugene M. Zuckert insists that Air Force management is a team effort. The other member of his team is "cigar and airman chewing" General Curtis E. LeMay. Says the Secretary, "Curt and I have a unique relationship." Says LeMay "we don't have too many arguments." To gain an insight into these men and the management methods they will use to carry out Air Force's aim of becoming the Aerospace Force, AEROSPACE MANAGEMENT sent its editors to get the story from them first hand. The photographs and article on pages 20-24 are the result of a series of EXCLUSIVE INTERVIEWS with Air Force's Management Team.

How NASA Plans To Use PERT . . . 24

All major civilian space projects will soon use NASA's version of PERT.
Main change from Navy concept is use of a single time estimate.

Army Accents Value Analysis . . . 30

Major contractors gathered in Pentagon to discuss cost cutting.
Subjects include personnel selection through design changes.

Design Changes—They Must Be Controlled . . . 38

Every prime contractor is sooner or later faced with a barage of design changes.
GE-MSVD has devised a management technique to control these changes.

Slashing Costs In Pershing's Propulsion . . . 44

Thiokol proposes thirty-nine ways to reduce propulsion costs.
Most radical is a switch to plastic-reinforced, filament-wound cases.

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Electronic AGE Market Due For Decline . . . 50

Many market analysists use past growth to predict the size of future markets. Author uses the "moral of the hand crank" to disprove this technique.

How To Improve Procurement Practices . . . 54

Special committee under Sen. Smather's direction diagnoses ills of DOD procurement and recommends specific cures.

Line of Balance Directs Decision-Making . . . 57

Each management echelon at General Precision Inc. uses this tool. It spotlights problem areas for them, while charting project progress.

Departments

Datebook	4	Market Planning	15	Worth Asking For	67
Editorial	7	Business Activity	17	New Parts and Components	68
Letters	8	Major Contracts	19	New Electronic Products	69
Projects	9	Men On The Move	63	New Production Equipment	70
Technical Advances	13	New Materials	64		

NEXT MONTH . . . LOOK FOR

A Special Staff Report on Pershing problems and progress, and how Martin-Orlando is using streamlined management techniques to cut costs and expedite deliveries . . . From North American Aviation's Space & Information Systems Div., details on a low-budget production control technique. ALSO: FALLOUT PROTECTION, should it be provided in the key aerospace plants, who's responsibility is it?

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Your Datebook

Dec. 2-5
Visual Communications Congress
Biltmore Hotel
Los Angeles, Calif.

Dec. 4-5
Beryllium Metallurgy Conference
New York University's
Washington Square Center
New York City

Dec. 4-6
Specialists' Meeting on Aerospace Support and Operations (classified sessions)
Orlando, Fla.

Dec. 4-8
Lecture-Workshop on Program Evaluation and Review Technique (PERT) and Critical Path Planning
Bureau of Conferences and Institutes, New York University
New York City

Dec. 5
11th Annual Meeting, National Air Taxi Conference
Statler-Hilton Hotel
Washington, D. C.

Dec. 5
Instrument Precision Ball Bearing Section, Critical Components Div.
American Ordnance Association
New York City

Dec. 12-14
Eastern Joint Computer Conference, Sheraton Park Hotel
Washington, D. C.

Dec. 18
25th Wright Brothers Lecture
Natural History Bldg.,
Smithsonian Institution
Washington, D. C.

Jan. 9-11
Eighth National Symposium on Reliability and Quality Control, Statler-Hilton Hotel
Washington, D. C.

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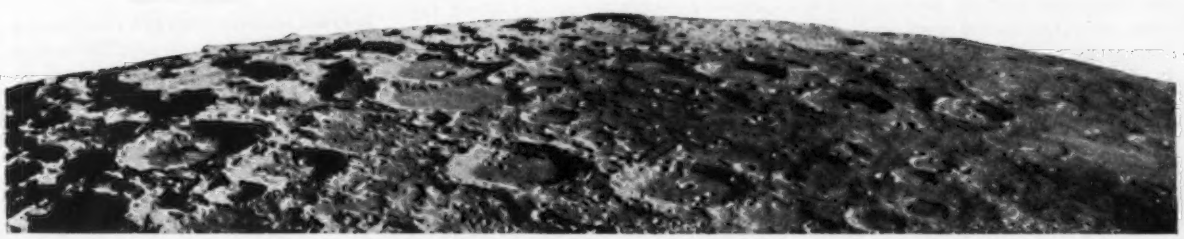

Arma navigates new routes

Navigating with cross-staff and primitive compass, Prince Henry's Portuguese pilots took more than 80 years to find a route around Africa and reach India. The Spaniards took another 20 years to cross the Atlantic and reach the shores of Florida.

Today, missile-borne inertial guidance can navigate such distances in a matter of minutes and pin-point targets nearly half-way around the world. Other advantages of inertial navigation are immunity to outside interference, all-weather capability, salvo firing, and a minimum of ground equipment.

Arma, designer of America's first inertial guidance of intercontinental range accuracy, has these systems in full production with on-schedule deliveries. Although specified for the Atlas missile, the Arma system is equally adaptable to other aerospace programs and space exploration projects.

At Arma, research programs currently are exploring smaller, supersensitive devices for future generations of missile and space guidance systems. Arma, a division of American Bosch Arma Corporation, Garden City, New York. . . . The future is our business. 8321

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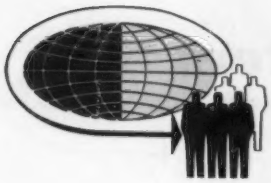

EDITORIAL

Who is Kidding Whom?

Reflection on Defense Secretary McNamara's decision to hold up spending on manned bombers reveals some curious facts. Somebody is kidding somebody.

According to published DOD reports, Skyshield II, a recent exercise to test the nation's defense against manned bombers, was 98 per cent effective. This looks good on the surface, but the deck was loaded. The so-called, training exercise used subsonic B-47's and B-52's as the "attacking" Force. They came in on known routes and known altitudes. Known, of course, by the defense network. There were no commercial aircraft in the sky to confuse the radars. And, all "friendlies" were probably operating with IFF "on," to aid in identifying them on the radar screens. Thus, every plain radar blip was a bogey. Under these conditions, the exercise most certainly should have been the success it was.

To equal the odds just a little, a DOD spokesman indicated that electronic countermeasures (ECM) were used by the "intruders." This brings our first question to mind. Since the exercise was 98 per cent effective, does this mean the ECM equipment now being used in B-52's and B-47's is 98 per cent ineffective?

Some time ago, an air-defense exercise similar to Skyshield II was held. It was called Skyshield I. The main difference in this exercise was that "intruder" aircraft included B-58 bombers. Time after time, the Mach 2, B-58's penetrated our coastal-radar-net though flying known routes and known altitudes. Even when picked up on radar, no intercepts were made. This has since been done repeatedly on many missions. B-58's even give periodic position reports during their escapades. B-58 aircraft were not used on Skyshield II. Why? Perhaps, DOD wanted the opportunity to announce that our air defense system is 98 per cent effective, at the same time it was announcing we would cut back on bombers.

There has been in recent times a great deal of talk by "officials in high places" about the number of vehicles we have capable of delivering nuclear weapons to target. Secretary of Defense McNamara wrote to one of our senators a few months ago that Air Force will have a fleet of 700 bombers B-52's and B-58's capable of delivering devastation upon a would-be aggressor. What he did not do was give the breakout on the 700 bombers. This breakout happens to be about 600 B-52's and 100 B-58's. Thus, a total force of 600 B-52 bombers would give us only 12 available at target against an air defense system that was 98 per cent effective. But, since B-58 can consistently penetrate such a network, it is possible that all of them might sneak through.

After the Tushino Air Show, Mr. McNamara announced that we had nothing to learn from this Russian demonstration. But, there was in fact a great deal to be learned. The Russians showed us a bomber that appeared to be at least equal to B-58 in performance. This means, that should the Russians put their minds to it they could develop a fleet of bombers that could "thumb its nose" at our radar defenses the way B-58 does. The Russians also showed us some pretty fancy interceptor type aircraft. The B-52 would hardly have a chance against these interceptors in numbers. However, the Mach-2 B-58 would have a chance of getting through.

Finally, keeping B-52 alive at the expense of B-58 is economic folly at this point. Our Mach 2 bomber has reached a state of development where it is actually cheaper than the B-52. We have already spent $3 billion on the development of the B-58. The third wing of this breed could be procured for approximately $346 million.

Now in light of all of this, is our radar net so good? Or are our bombers so bad? We believe that there is an attempt to convince the public and the press that the defense network is infallible and that bombers are obsolete. However, in actual fact the situation might be just the opposite. There are breeds of aircraft, flying today both in the United States and Russia, that could slip through existing radar networks without any serious fear of detection.

Tom MacNew

Editor

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Letters

A Blow For Freedom
Our Greatest Weapon Being Phased Out

. . . Congratulations on your fine October editorial on ever increasing Government controls which are, in effect, phasing-out free enterprise in the Aerospace Industry. The measures you recommend would help to slow down the rate at which our segment of the economy is being injected with ever-increasing doses of that narcotic called Socialism. (If this sounds strong, reflect for a moment that the *only* significance to ownership is control.) I would like to point out, however, that restoration of private control and competitive vitality to our industry (and other areas of our economy) requires positive corrective measures and not merely spotty resistance to further Government encroachments.

J. F. Smith
National Management Assn.
San Diego, Calif.

Wants To See More

. . . I enjoy reading the AEROSPACE MANAGEMENT publications, especially articles on value analysis. I hope you will continue to include these informative articles in your future issues.

L. E. Stegman
Manager, Value Analysis
Electronics & Ordance Div.
Avco Corp.

. . . Your new magazine AEROSPACE MANAGEMENT is most interesting. It is fulfilling a void in management reading.

Early R. Hartley, Chief
Special Projects Branch
HQ, San Bernardino Air Materiel Area
United States Air Force

. . . The article by Robert E. Beach in your November, 1961, issue is certainly timely.

W. S. Blackmen
Director of Advertising,
Bird Electronic Corp.

. . . I have just read your article "How To Make Value Analysis Work" published in your November, 1961, issue. I enjoyed this article very much.

Robert L. Leming
Procurement Value Analyst
McDonnell Aircraft Corp.

Timely and Refreshing

. . . You are to be congratulated on publishing two such timely articles as "Small Business is a Big Problem" and "Management Worried . . . Government Controls Oppressive." It is certainly refreshing to have two gentlemen such as Mr. Beach and Mr. Black express themselves on the subject so emphatically.

Hugh C. Robbins
President,
Robbins Aviation, Inc.

Portrays the Facts

. . . We wish to compliment you on the excellence of this article ("Management Worried") which is a hard hitting, factual portrayal of conditions as they presently exist for government contractors.

J. T. Shelton
Vice President,
Land-Air, Inc.

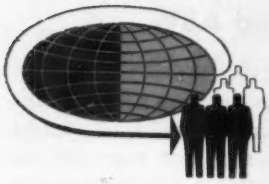
. . . The articles in the September issue are of particular interest to our growing engineering team, and I would like to thank you for continually bringing timely information to our attention.

D. A. Gehlke, Vice President
Corporate Director of
Advanced Development
Babcock Electronics Corp.

Keeps Him Up-To-Date

. . . I want to express my appreciation for the very excellent studies and articles appearing in AEROSPACE MANAGEMENT. I am proud to include it with the important publications I read to keep abreast of the industry.

Howard A. Zeimer
Director, Military Liaison
Marks Polarized Corp.



Projects

Missiles and Space Vehicles

ATMOS—Solid-fueled rocket motors, designed by B. F. Goodrich, have internal burning grain design. Maximum thrust exceeds 1500 lb for eight sec at 80° F. Motor has four and one-half in. diam and is capable of lofting 12 lb payloads up to 300,000 ft.

ATLAS SILO—45-ft-high launcher platforms for Atlas-F designed by American Machine and Foundry and built by U. S. Steel weigh close to 75 tons each. Overall vertical tolerance on structure is ⅛ in. with horizontal tolerance of 1/16 in.

LARGE ROCKET PROGRAM—Aerojet General and Rocketdyne are carrying out parallel research for NASA into 2-24 million lb thrust engines. Both companies are searching for a highly reliable "unconventional" engine and vehicle design concept for a rocket stage which can be developed and produced with significant savings over existing concepts.

LIQUID PREPACKS—The concept of the liquid prepack engine, developed by Reaction Motors for Navy and Martin in the Bullpup program is drawing interest and funding from the military for big-booster applications. This simple approach to liquid rockets eliminates plumbing almost entirely. It also cuts weight and increases reliability. Large-booster prepacks would be assembled and loaded on site.

MAULER—The Army's solid propelled mobile battlefield missile is into its second phase of test firings at White Sands after successful completion of the first.

MIDAS—Future military commanders analyzing infra-red sensed data will view the data instantly in normal light with multi-colors on a large size screen. A Situation Display Console, is being developed by General Electric for use with AF's Missile Defense Alarm System (MIDAS). Heart of display equipment is Military Electronic Light Value projection system known as MELVA.

MINUTEMAN—There is very strong belief that Air Force will soon announce an "advanced Minuteman" weapon system study. R&D contract will be largest ever awarded by a government agency—over $500,000,000. Muscleman, Midgetman, and other "man" breeds will be studied.

OAO—General Mills is producing computers for use in NASA's Orbiting Astronomical Observatory Program. Computers will be installed at ground stations in NASA's minitrack network to perform data processing of orbital and tracking data.

PERSHING — A zig-zag flight successfully tested Pershing's inertial guidance and control system. Pre-set maneuvers were most severe test of system to date.

PERSHING—Filament wound motor case for Pershing is an on-again-off-again situation. Thiokol thinks it can make the conversion pay after turning out 20 motor sets. Estimated savings would be $20,000 per set. Martin and Army are interested in plastic cases but are not sure filament winding is the answer.

POLARIS A2—Successfully fired from underwater. A2 has increased range of more than 300 miles over A1 version.

SATURN—Successful Oct. 27th launch marked first major milestone in Saturn program. NASA has selected Chrysler Corp. to build, check out, test and launch the S-1 first-stage booster. Work will be done at NASA's Michoud plant. Construction of 20 S-1 boosters will extend through 1966. Contract is estimated at over $200-million. Aerojet will aid in testing and give launch support.

NASA and DOD seem to be leaning heavily towards the use of the orbital rendezvous concept for a manned lunar landing attempt. The Saturn C-4 would be primary launch for orbital rendezvous operations. Large liquid Nova development would continue for direct moon flights.

SEABEE—The rocket fired from the ocean off Point Mugu scored a double first by being used again in a similar test. The original flight was the first time a liquid fueled rocket had ever been fired from the ocean. In the second ocean firing the SeaBee, a modified Aerobee-100, went about 5000 ft before dropping back into the ocean without benefit of its parachute which failed to open. Floating launch method was first used by the Navy using a solid rocket in the Hydra series of tests.

THOR—Thor was recently launched successfully for the 100th time in a total of 129 firings. 13 of total launches were considered "partially successful." NASA has ordered 14 more Delta vehicles based on the Thor first stage with an improved Rocketdyne

Projects

continued

engine of 170,000 lb thrust. Delta second stage is an Aerojet liquid engine AJ10-118 of 7500 lb thrust with an ABLE third stage solid rocket of 3000 lb thrust. Deltas will be used to launch communications satellites in NASA's Relay and Syncom series, AT&T's Telstar series; Tiros meteorological satellites, and the first United Kingdom satellite project S-51. Of the original order of 12 Delta vehicles six have been launched, five successfully.

X-15—Top speed was reached last month. X-15 flew 4070 mph despite windshield breaking for second time. Skin temp reached 1100°F. New autopilot was tested during flight. Minneapolis-Honeywell's adaptive autopilot device blends aerodynamic flight reactions and reaction controls.

X-15—Thrust of the XLR-99 engine could reportedly be increased 100 per cent using a powerful new oxidizer, oxygen difluoride (OF_2) now being studied by Thiokol Chemical Corp. The company is now investigating patentability of the oxidizer.

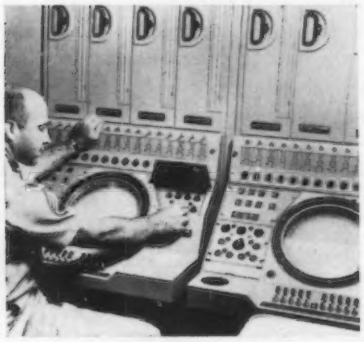
Aircraft and ASW

AIR CARGO TRANSPORTS—Douglas Aircraft predicts future bright for air cargo which is currently a fraction of one percent of total U. S. freight movement. Survey indicates need for two new air freighters, one for 20 tons payload operating up to 800 mi and another for five tons up to 200 mi range. VTOL and STOL capability an advantage for these concepts.

ARTEMIS—A five-story sonic transducer will be lowered and raised in the water as part of Navy's long-range submarine detection project (AM, July 1961).

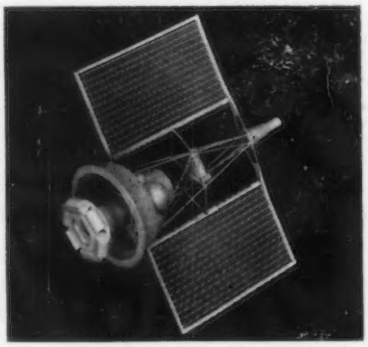
BOEING 727—The first production jig for the medium transport has been loaded. Peak tooling workload to be reached next year. Approximately 1200 people are currently employed in tooling the 727 in three divisions. Sales to date number 117 airplanes.

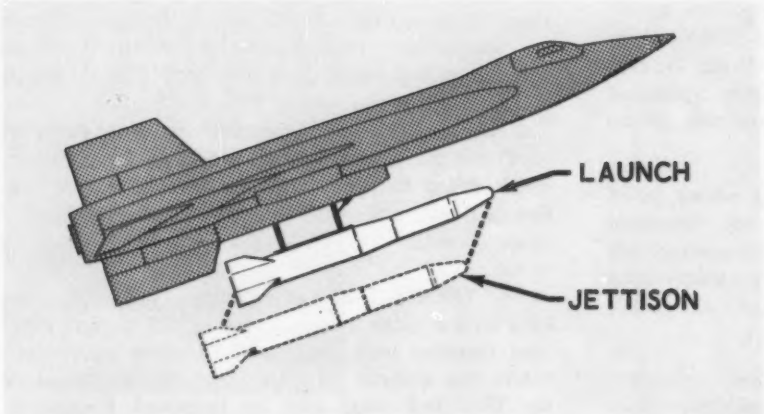
CARAVELLE—Panair Do Brasil has purchased four Sud Aviation Carabelle VI-R transports with an option on two more. Sale was coordinated by Douglas Aircraft, making the fourth sale and 47 aircraft sold in the Douglas area.



◀**HELILIFT,** helicopter-carried fire coordination system will be used with Nike and Hawk missiles. Hughes Aircraft developed system, consisting of one operations central (left) and four or more coder-decoder units.

SNAPCRAFT concept will first be ▶ designed to test Snap-8 and checkout various electric engines. Advanced versions could stop, turn and drive around solar system according to Space-General.





◀**X-15/BLUE SCOUT** concept proposed by Ford's Aeronutronic and North American Aviation would provide AF with recoverable space booster system. B-52 would carry X-15 aloft. After Blue Scout leaves X-15 launch rails, the rails are retracted into X-15 pylon. Blue Scout could be jettisoned and recovered should abort be necessary. Concept is said to offer two-thirds cost savings over present guided or orbital Blue Scout launches, and reduce cost of probe or unguided missions by half.

CARAVELLE—An automatic landing system for the Caravelle jet is being developed jointly by Lear, Inc., and SUD Aviation of France.

DC-8—FAA has approved re-shaping of leading edge on wing to increase range and speed of Douglas DC-8. Change will be made on existing aircraft and will be incorporated on the DC-8F Jet Trader. A DC-8 flew beyond Mach 1 with the new leading edge. (AM, Oct. 1961)

F-104G—The first German assembled F-104 fighter has officially joined the German Air Force. The first aircraft was assembled on a Messerschmitt production line. Other F-104's will be assembled at Heinkel, Dornier and Siebel making a significant regrowth of the once defunct German aircraft industry.

F-105D—In a successful test to check out the F-105D's automatic target-seeking computer system, the Mach 2 jet launched a Sidewinder which destroyed an unseen jet drone.

G.E. T-64—Turboprop engine flight testing is being initiated in a de Havilland Caribou. The T-64 powers the tri-service VTOL transport to be jointly built by Ling-Temco-Vought, Ryan and Hiller.

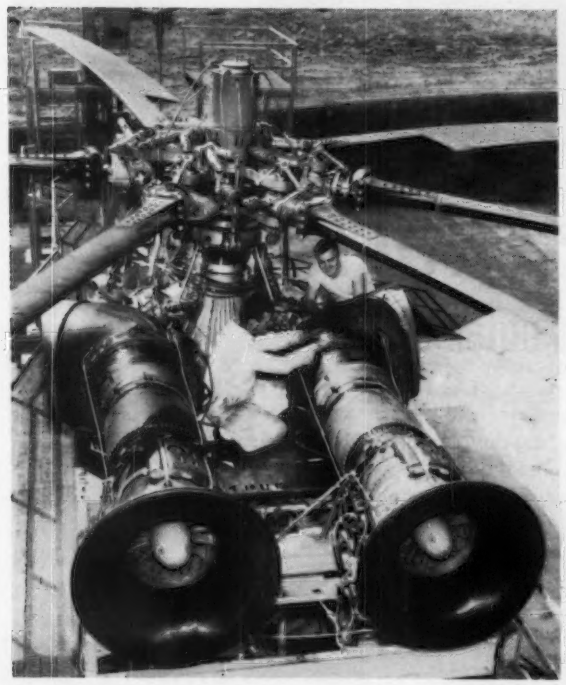
H-43B HUSKIE—The AF has claimed a new world altitude record of 32,000 ft for the Kaman-built Huskie. Three new time-to-climb records are also claimed. Highest altitude in records is 29,526 ft; Huskie climbed it in 14 min 11.5 sec.

HILLER HELICOPTER—Six place Model "Ten 99" powered by a Canadian Pratt & Whitney PT6 turbine engine is aimed at Navy, Marine, and all purpose civilian market.

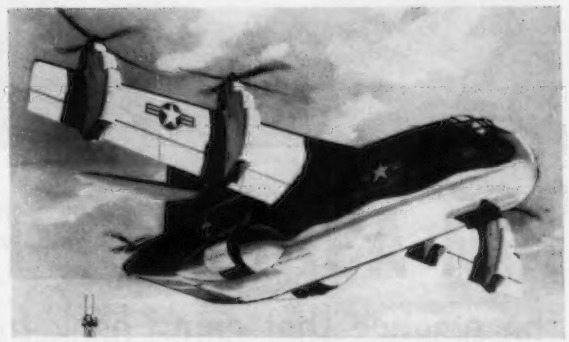
SST—The Air Force awarded a study contract to General Electric to determine optimum type of powerplant for a supersonic jet transport. The FY62 budget includes $11-million for SST studies.

T-38—Total sales have risen to 357 aircraft. Northrop T-38A trainers are being produced at a rate of 12 a month in Hawthorne and Palmdale.

VTOL—Ling-Temco-Vought, Ryan Aeronautical and Hiller Aircraft will develop the tri-service VTOL transport (Artist's conception shown below). Chance Vought will serve as prime. Ryan will design and build aft section assembly, including tail surfaces, engine mounts and nacelles. Hiller will handle power transmission systems, gearing, shafting, propellers, flaps and ailerons. Four General Electric T-64-GE-6 turboprops will be mounted on a tilting wing. VTOL will have a top speed of 400 knots at sea level.



SKYCRANE rotor systems and two free turbine versions of Pratt & Whitney's JT-12 jet engine undergo conditions of flight in a test bed at Sikorsky plant. Two of the 870 lb, 4050 hp engines will power the Skycrane, which is capable of lifting payloads of up to nine tons.



VTOL aircraft will be built by team of Ling-Temco-Vought, Ryan, and Hiller as tri-service transport. Contract calls for development and fabrication of five experimental models.

B-58 rocket-powered escape capsule was jettisoned during 115 mph runway test at Edwards AFB. Capsule will shield three-man Hustler crew during ejection.

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Technical Advances

Ion engine uses the principle of electrostatic propulsion to gain thrust by ionizing cesium atoms and accelerating them out the rear of the engine. An ion engine uses about 20 or 30 times less fuel to produce a lb of thrust than a chemical rocket. Hughes-built ion engine and one built by the Lewis Research Center will be tested in space next year.

Lightweight turbine driven by a rocket's exhaust gases instead of heavy power sources, can power pumps for liquid propellants and oxidizers. A small solid propellant charge is used to start rotation. Fuel system was designed at Army's Airborne Test Activity, in Yuma.

Magnesium-lithium alloys are 20 per cent lighter than magnesium and more ductile due to crystal structure alteration. Alloys are resistant to penetration by high velocity particles. Battelle Memorial Institute conducted research on alloys containing 11 per cent or more of lithium. Weight of magnesium-lithium alloys is about three-quarters that of magnesium, half that of aluminum and one-quarter that of stainless steel.

Electric power can be produced by heating certain metals that are separated by a porcelain enamel. This new power conversion method was discovered by B. O. Austin of Westinghouse's aerospace electrical dept. AF has awarded Westinghouse a $75,000 contract for further study of the Austin Cell. Such a cell could produce power from a rocket's waste heat.

High purity ceramic production method developed through AF research project. Direct metathetical precipitation of tetragonal barium titanate powder was used to produce 99.95 per cent $BaTiO_3$ in pre-pilot plant lots. A pilot plant was designed which can produce 25 lb lots. ITT researchers feel pilot plant is versatile enough to also produce compounds of zirconate, niobate, and tantalate groups with equal purities.

Satellite display system can display six satellite tracks simultaneously. Tracks are visually presented on the face of a large-screen cathode ray tube on which a transparent Mercator projection overlay of the earth is superimposed. Real-time positions are shown as intensified spots on respective tracks. Satellite information is converted to punched tape and computer stored. Operator can callout information by pointing a "light gun" at his target of interest. System was designed at the AF Cambridge Research Lab.

Polyurethane foam substituted for conventional sandwich construction components, results in a cheaper, lighter and stronger fin for rockets, according to an AEC study.

Communications system makes fighter plane interception of a target as automatic as it is with an unmanned missile. System, known as Time Division Data Link (TDDL), has proven successful in tests by the Electronic Systems Div., AF Systems Command. TDDL was flown in F-102 nose during tests from Hanscom Field. System enables one machine to give instructions to hundreds of airplanes faster than any other known means. When an aerial target is detected, TDDL receives command instructions from a ground-based computer in coded form. Computer directs distribution of commands to transmitter sites throughout the country. Instructions are then beamed to the aircraft. Message is decoded and displayed on the pilot's instrument panel. Command can be passed directly to an automatic pilot for ground control of intercept.

Airframe bearings of titanium carbide and cobalt alloy, when teamed with stainless tool steel and chromium carbide rings can withstand temp of 1200°F. General Motors' New Departure Div. study for AF indicated that none of 25 lubricating aids tested with the bearings significantly improved bearing performance.

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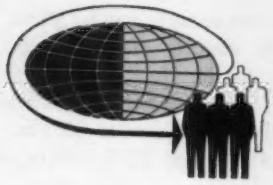

Market Planning

BUDGET REVIEW

The Kennedy Administration, in announcing what it termed a non-inflationary budget deficit of $6.9-billion for FY62, traced a large portion to increased outlays for defense and space spending.

In a move to offset this record deficit, President Kennedy has called for an economy-drive through better management. He has asked all agencies "to exercise the maximum care in scrutinizing all expenditures, tightening requirements, postponing the initiation of deferrable projects, and phasing out any acceleration of spending which was initiated as an anti-recession measure."

The Budget Bureau reported some cost-cutting actions already initiated that will affect some markets directly; others indirectly.

- In the AEC, modifications in uranium procurement contracts affecting pricing and deliveries will result in savings of $16-million. Improvements in the operation of gaseous diffusion plants will produce an estimated annual saving of $4-million.
- Improved supply management procedures by NASA will save an estimated $3.4-million.
- DOD has launched a program to reclaim spare parts from aircraft to be scrapped, with savings estimated at $100-million annually. Reduction of some military inventories will permit deactivation of storage space at an annual $26.8-million saving.
- The newly established Defense Supply Agency, over the next several years, can reduce inventories by about $2-billion through improvements and economies in defense logistics management.

Extra Funds Ignored—Although not listed as a major money-saving move, Defense Secretary McNamara has decided not to spend the extra $780-million voted by Congress for more B-52 bombers, and increased B-70 and Dyna-Soar development.

DOD announced that "progress of the administration's accelerated defense buildup make unnecessary the use of additional funds appropriated by Congress."

The Boeing Co. said the administration's decision will have no immediate effect on the company's Wichita operations. Current firm orders for B-52's will extend deliveries into the fall of 1962. "In addition present and possible future modification work on the current fleet of B-52's will extend into 1964," Boeing said.

Defense Secretary McNamara, in announcing the decision, said it "in no way means that our bombers are becoming obsolete." McNamara added that our current force of 1500 heavy and medium bombers, with supporting tankers, gives the U. S. more than enough aircraft capability through the 1960's and into the early 1970's.

DOD has not changed its position on the B-70 development program since Congress added extra funds. A three-aircraft prototype effort "permits the continuation of essential technological developments and retains the option to proceed with the development of a complete weapon system at a later date."

A review of the Dyna-Soar program did not convince the administration that it needed more than the $100-million requested for FY62.

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GILPATRIC FORECASTS $18-BILLION FY62 PROCUREMENT

Deputy Defense Secretary Roswell L. Gilpatric predicts nearly $18-billion in actual procurement contracts and a "somewhat higher" total in FY63. Gilpatric indicated that total operating expenses are now running about $28-billion annually and R&D, test and engineering expenses . . . "will rise from nearly $7-billion in the current year to close to $8-billion the year after." Purchase of weapons, other military equipment and construction of bases will run $14-billion this year and will rise in FY63.

"Outlays for aircraft are on the way down . . . they will run over $6-billion this year but less than $6-billion next year. Missile costs, both for ICBM's and for shorter range tactical missiles and rockets, are still rising, from $4.6-billion this year to a slightly higher figure next year." Gilpatric added that Navy shipbuilding of about $3-billion annually will continue as long as DOD maintains the present fleet of over 800 warships and supporting vessels."

In line with President Kennedy's request, Gilpatric said "significant savings" can be made in developing new weapons systems. "We can no longer afford to finance such developments on a separate service basis. Where one system can meet the need of two or more services, it should be developed on a multi-service basis. A good start has been made in this direction in the development of a STO transport, the tri-service air superiority fighter and the tri-service attack aircraft. We hope to extend the same system approach to surveillance drones, general utility aircraft and to MRBM's if it is decided to go ahead with such a project."

Major military procurement in FY62 will be about $1,342-million higher than in FY61. Polaris and Minuteman will receive particular emphasis. Expenditures for Atlas and Titan will also be increased.

Increased aircraft procurement for the Air Force will provide 99 C-130's and 45 C-135 jet transports. Navy will get additional A4D-2N, F8U-2N and F4H-1 aircraft. Army will receive additional helicopters and fixed-wing aircraft.

Stepped-up tempo of operations is estimated to increase operations and maintenance spending by $981-million. Research, development, test and evaluation expenditures will be $174-million over 1961.

AEC spending will be $32-million below 1961 expenditures. Increases due to resumption of nuclear testing, expansion of research programs in physical and life sciences, and acceleration of the Rover nuclear rocket program and of the SNAP small-atomic-power-source program, will be more than offset by reductions in uranium procurement and by scrapping of the Aircraft Nuclear Propulsion (ANP) program.

Space Spending—Actual space spending in 1962 will grow to about $2.5-billion. This represents direct government spending and does not account for allied projects funded by industry. By 1966 projected space programs should total $10-billion. The probable breakdown is shown in the following table:

	Millions of Dollars		
	1960	1962	1966
NASA	339	1672	7000
Military	561	1079	3000
AEC	43	79	500
Total	943	2830	10,500

Projects Nimbus and Tiros, basic meteorological systems, call for expenditures of $50-million in FY62. Echo, Rebound, and Relay Communications projects are drawing $91-million in FY62. By 1966, spending for these projects will multiply. However, the biggest amount of money will be directed into Apollo, Saturn, and Nova.

NASA—Expenditures in 1962 for the civilian space programs of NASA will be $591-million higher than in 1961. Prime efforts are directed toward placing a man on the moon; speeding up the nuclear rocket program; expansion of the meteorological satellite program; and acceleration of communications satellite development.

Administrator James Webb said NASA's FY63 budget will double 1962 funding of $1.6-billion to meet the administration's new goals.

The supersonic transport program is one of these goals. The SST will require "many million of dollars" and attempts to overcome associated problems may extend into the 1970's, Webb said.

FAA expenditures will require an increase of about $81-million above 1961. Improvement and modernization of the Federal airways system is being accelerated. A new study is being made to determine technical and economic feasibility of a supersonic air transport for civil use.

Subsidies paid by CAB to support airline operations will be increased by $5-million.

NEAR/MID EAST AVIATION OUTLOOK

The U. S. aviation industry can expect strong competition in the Near and Middle East from Europe, especially in sales financing. Lack of adequate surface systems increases dependence on air transportation in the area.

A study by the Business and Defense Services Administration indicates, "Economic development is needed not only to create demand for airplanes, but also to provide the financial resources to pay for them."

U. S. exports of aeronautical products to the Near and Middle East in 1960 were valued at about $4.8-million, compared to $3.3-million in 1958, and $2.3-million in 1959.

MACHINE TOOL FUNDS

The Defense Department will have $100,000,000 available for the purchase of machine tools and production equipment in FY62. Sixty per cent of this will go directly to the aerospace industry. (AM October, 1961)

Most of the funds have not been committed, but it is expected that they will be by July 1, 1962. The $100,000,000 will be allocated to the three services as follows:

Air Force	$60-million
Army	$25-million
Navy	$15-million

About 60 per cent will be used for replacement of machine tools and about 40 per cent for new production lines.

RESEARCH FORECAST

Research spending in the U. S. will amount to almost $16-billion in 1962. Government will spend about $10-billion for research next year, reflecting stepped-up space and defense programs. Industry's research bill will be about $5.5-billion, up $600-million from the 1961 estimate. Universities and foundations will spend another $350-million. By comparison, research spending totaled $14-billion in 1960 and only $3-billion in 1950.

Government supported 57 per cent of all research in the U. S. in 1960 and it is likely that it will continue for some time to provide over half of all research funds.

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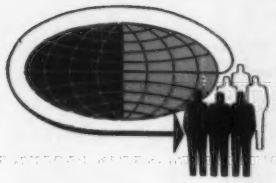

Business Activity

Growth of PERT

Since the first PERT (Program Evaluation and Review Technique) program was completed in 1958, its use has spread through the military and industry. (NASA-PERT story, this issue. AM, Oct. 1961; AM, Sept. 1961; AM, Aug. 1961.)

The RAF and British aerospace industry recently invited J. W. Pocock, president of Booz, Allen Applied Research, Inc. to discuss PERT with them. Pocock said that Booz, Allen & Hamilton has surveyed American industry and found that:

- Nearly half of the 100 largest U. S. defense primes are using PERT.
- At least 70 per cent of the 75 R&D firms with the largest government contracts are using PERT.
- At least 50 U. S. companies are using PERT to reduce time and costs for nonmilitary projects.
- Over 30 different models of U. S. computers have been programmed to run PERT data and analyses.
- Nearly two dozen U. S. aerospace projects are using PERT.

Pocock predicted that there will be more applications of PERT in 1962 than its total uses in the last three years.

Money-Saving Facility

Republic Aviation Corp. expects to be able to handle over a million dollars' worth of production work in its new milling facility, that otherwise would have to be subcontracted.

The new $180,000 chemical milling facility will be used to produce aluminum parts for the F-105D. It is part of Republic's overall F-105D cost-reduction program started in FY59. Aim is to shave a million dollars from F-105D costs by FY62.

The company expects to save $125,000 a year with the new facility. Republic holds a sub-license on the chemical milling process which was developed and patented by North American Aviation.

White Rooms Obsolete

Industrial white rooms have reached their limit of effectiveness, according to Stuart L. Parsons, general manager of the Equipment Manufacturing Operations of Philco Corp.

Recent high volume production rates and the increasing advances in solid state science have greatly compounded atmosphere control problems. The net result has been an obsolescence of the white room approach.

The white room approach always results in a high cost of construction and maintenance. The cost of establishing white rooms in existing buildings often approaches the cost of the production equipment itself.

Adequate and economical environmental control for today's expanded semiconductor industry can only be obtained by very close control of contaminants in very limited areas; within larger "clean room."

No Hurry on Comsat Policies

The President's special White House Space Council has hung a "no hurry" label on its study of government patent policies on communication satellites.

A spokesman for the Council told Aerospace Management that the group will take its time probing for conflicts, similarities or overlapping in patent policies, chiefly among the top three federal agencies involved: NASA, AEC and the Defense Department.

The Council says no new contracts in the field will be negotiated next year. All present contracts contain a patent rights clause, the council says, so there is no need for a government-wide policy before 1963.

Small Business Pool

Four small firms in the New York City area have formed a pool to perform government R&D contracts. The Small Business Administration approved the move.

The N.Y.R.A.D. Team, Inc., will seek R&D contracts in physics, radiation, optics, inertial guidance and electronics. By pooling, the four firms are in a better position to compete for prime R&D contracts than they would be individually.

Included in the pool are: Aerolite Electronics Corp.; Manhattan Physical Research Group, Inc.; New York Testing Laboratories Inc.; and Radiation Research Corp.

Industry Notes

United Aircraft Corp. has formed a Solid Rocket division to support its subsidiary, United Technology Corp. The new division will act as a basis for ultimate volume production by UAC of solid rocket motors.

Lockheed Aircraft Corp. reported a net profit for the first nine months of 1961 of $16,502,000 or $2.20 a share. Earnings for the third quarter were $7,279,000, compared with $5,485,000 for the comparable 1960 period.

Lockheed Propulsion Co. is the new name of Lockheed's Grand Central Rocket subsidiary.

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B. F. Goodrich Co. reported net sales of $559,690,620 for the first nine months of 1961, 4.8 per cent under the same period in 1960. Dividends of $1.65 a share of common stock were paid for the first nine months of 1961 and of 1960.

Taylor Fibre Co. has opened a warehouse in Hartford to give overnight delivery in the New England area. The warehouse stocks fabric-base and glass-base laminated plastics and glass-epoxy copper clad laminates.

Radiation Inc. reported sales for FY61, ended August 25th, of $26,244,383. Net income was $.60 per share, compared with $.20 for 1960.

Purolator Products, Inc. has acquired On Mark Couplings, Inc. On Mark will be operated as a wholly owned subsidiary with Barry B. Willis and Herbert DiCenzo remaining as president and vice president respectively.

Martin-Marietta Corp. is the new name of merged American-Marietta Co. and The Martin Corp. Sales of both companies totaled over $1-billion in 1960. Martin's current backlog of defense contracts is over $1-billion. More than $200-million in Pershing contracts have been received by Martin since June.

The Garrett Corp. had sales for the first quarter ended Sept. 30, 1961 of $47,891,854. Earnings were $1,040,521 or 72 cents per share.

Boeing's Vertol Div. and Westland Aircraft Ltd. of Great Britain have signed a ten-year agreement. Westland will make, sell and service the Boeing Vertol 107. The 107 can be powered by the De Havilland Gnome or by the General Electric T-58-8 turbine engines. The Gnome engines would probably be used in production by Westland.

TOP TEN IN R&D

Dollar volume of top ten research and development contractors for the 1949-1959 period.

CONTRACTOR	R&D Contracts	Company Invested	% Sales to Government	PATENTS Applied for	Granted	Pending	Used commercially
North American Aviation	$1,975,000,000	15,000,000	99	391	172	191	4
General Electric	1,500,000,000	1,370,000,000	25	804	471	258	40
Sperry Rand Corp.	854,272,580	132,522,231	42	488	252	225	10
Hughes Aircraft	800,000,000	28,400,000	96.6	458	174	225	4
Western Electric	760,000,000	576,978,000	24.3	419	247	160	3
The Martin Co.	739,254,000*	9,064,000	97.4	120	79	41	**
Aerojet-General	689,745,717	3,596,833	98.9	328	25	203	0
United Aircraft	502,000,000	616,000,000	86.3	278	171	85	38
Northrop Corp.	414,178,814	10,241,105	90	361	328	33	0
Raytheon Co.	325,000,000	38,000,000	59	376	212	112	4

* For 1954-1959.

** 42 licenses granted to members of Mfg. Aircraft Assn., no royalty income

MANAGEMENT QUOTES

Ogden Johnson, v.p., Ford, Bacon & Davis, Inc., consulting engineering firm: "The impersonal engineer with his slide rule and formulas . . . may be a dud in the executive suite." Engineers, he added, are the second largest group among chief executives of America's leading corporations. Automation and the increasing complexity of modern business require an engineer on every management team. "Yet the engineer's technical training too often leaves him weak in interpersonal relationships and articulate communication."

Winford T. Higgins, asst. to v.p., marketing, Intercontinental Electronics Corp., also spoke on air traffic control: "Certain military organizations have defined radar as their primary air traffic control system until at least beyond 1975. All their training and procurement is being oriented accordingly."

Dr. John A. Hutcheson, v.p., engineering, Westinghouse Electric Corp.: "The United States may have a new method of power generation operating on the moon before one is operating full-time on a power company's lines."

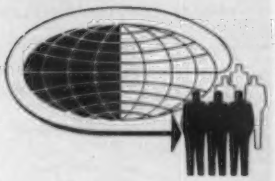
Maj. Gen. W. T. Thurman, director of Air Force procurement management, said the A.F. won't conduct its new policy of increasing reward and penalty features of its contracting by "fiat." For instance, "bringing a missile into production six months earlier than scheduled might do no good at all because the sites might not be ready, or the crew properly trained. We won't indiscriminately pay extra for higher performance, for greater reliability or earlier delivery . . . but we will consider improvements that give us an extra margin of defense . . . a reliability improvement in a transistor that is used in a missile would be extremely valuable. On the other hand, extending the range of that same missile by even 1000 miles might be operationally valueless."

Joseph S. Imirie, asst. A.F. secretary, materiel, outlined new demands A.F. will make of industry before current administrative profit restrictions are relaxed. "We will consider proposals for profit levels that exceed the administrative limitations all the way up to the 15 per cent statutory limitations . . . but you can be sure we will do so only when the contractor's performance far exceeds predetermined standards."

MAJOR CONTRACTS

CONTRACTOR	VALUE (Millions)	FROM	PROJECT	PRODUCT/SERVICE
ACF Electronics	.5	NAA	Hound Dog	Radar beacons
Acoustica Associates	2.7	AF	Atlas	Propellant system
Adler Electronics	1.5	General Dynam.	—	Com-system
Aerojet General	5.0	AF	Titan I	Test and analysis
	1.3	Navy	—	Com-system equipment
	1.2	Navy	—	Rocket motors
	2.2	Navy	Jato	Rocket motors
	1.1	AF	—	Missile test kits
	4.5	AF	Thor-Able-Star	Build and checkout second stage
Air Products & Chemicals	1.7	NASA	Saturn	Liquid hydrogen service system
American Bosch Arma	17.6	AF	Atlas	Inertial guidance
	1.0	AF	Atlas	Inplant support
	9.6	AF	Atlas	Guidance
Avco Corp.	65.8	Army	VRC-12	Radio systems
	3.8	Aerojet	Minuteman	Rocket chambers
Bendix Corp.	10.9	Navy	—	Pacific range operation
	4.5	Army	Advent	Comsat modifications
Benrus Watch Co.	2.0	—	Sidewinder Hawk Sparrow	Launchers, power supplies, guidance and control, and other components
Boeing Co.	1.1	AF	Minuteman	Site support work, Hill and Whiteman AFB
	1.1	AF	Minuteman	
	8.7	Navy	HRB-1	Helicopters for Marine Corps
Bridgeport Brass	4.2	Navy	Zuni	Parts
Bulova Watch	1.0	AF	Minuteman	Safing-and-arming igniter
Butler Mfg.	2.2	Navy	—	Aluminum landing mats
Cameron Iron Works	2.7	Navy	Terrier	Boosters and sustainers
Compudyne Corp.	1.6	AF	J-57	Engine test stands
	1.9	AF	Titan II	Hydraulic systems
Conco Engr. Works	1.0	Navy	Mark 104	Practice bombs
Control Data	1.1	Navy	—	1604 computer
	.2	Raytheon	Sparrow III	Components
Curtis-Wright	6.2	AF	—	Engine parts
	10.0	AF	C-124 C-133	Modify prop assemblies and components
Dallas Airmotive	1.9	AF	R-2800	Overhaul engines, parts
Douglas Aircraft	6.9	AF	—	Develop facility for rocket fuze production
	1.7	Army	Nike-Hercules	Production
	19.0	NASA	Delta	Produce 14 vehicles
	57.7	Army	Nike-Zeus	Continue development
Dynamics Corp. of America	2.1	AF	—	Ground power plants
Eastman Kodak	1.1	Navy	Sidewinder	Fuzes
Eby & Associates	6.4	AF	Titan	Construct launch site, McConnell AFB
Electronic Assistance	5.0	NATO	—	Radar equipment
Elgin National Watch	1.1	Navy	Bullpup	Fuzes
	2.9	—	Sparrow, Sidewinder, Tartar	Production
Farmers Tool & Supply	1.0	Navy	Sidewinder	Wing assemblies
Fluor Corp.	7.0	AF	Titan	Launch facility, Davis-Monthan AFB
Ford Motor Co.	8.0	Army	Shillelagh	Continue development
Garrett Corp.	1.2	AF	F-105	Constant speed drive
General Dynamics	2.5	AF	—	Design, nuclear systems
	1.8	Navy	Bumblebee	R & D
	13.0	Army	Mauler	Continue development
	3.0	Army	Nike Ajax Nike Hercules	—
	25.0	Navy	Terrier-Tartar	Guidance control
	4.8	AF	—	Training facility
	20.0	AF	Atlas F	Support equipment
	3.2	AF	Atlas F	Training site
General Electric	72.9	AF	J-79-GE-8	Turbojet engines
	1.5	Navy	Polaris	Spare parts
	45.7	AF	Classified	Classified
	24.9	AF	—	Ground electronics
	6.4	AF	Titan	Site com systems
	1.0	Navy	Sidewinder	Guidance equipment
	1.1	AF	—	Radar warning device
	3.0	NATO	F-104	Engine components
	2.0	Army	Vulcan	Production
	2.9	Navy	Sidewinder	Guidance equipment
	34.4	AF	T-38	Engines
	2.0	AF	—	Telemetry
General Motors	2.0	AF	Titan	Training
General Precision	2.2	AF	C-130, KC-135A, SC-130B	Components, spare parts, ground equipment and tech publications
	1.0	AF	T-37, B-58	Service, Link trainers
	1.9	Navy	S2F	Trainers, Link
	1.0	AF	—	Landing system
Goodrich, B. F.	1.1	Navy	—	Aircraft de-icer boots
Grumman Aircraft	11.8	Navy	Hydrofoil	Design, production
Hallicrafters Col	8.3	AF	B-52	Com equipment
Hazeltine Corp.	1.9	AF	T-38, T-39	Transceivers
Hercules Powder	3.0	Navy	Polaris	Propellants research
	4.3	AF	Minuteman	Third stage engines
Holston Defense Corp.	11.6	Army	—	Propellants, explosives
Hughes Aircraft	2.9	AF	F-106	Sight and antenna
	1.4	AF	—	Radar work
	3.0	Navy	—	Fire control systems
	5.0	Navy	Polaris	Guidance
IBM	14.5	AF	B-52	Components, nav-system
ITT	1.8	AF	—	Com systems
International Aircraft Services	1.5	AF	C-121	Recondition 25 aircraft
Johns Hopkins U.	11.1	Navy	Bumblebee, Transit	Continued research
Kollsman Instrument	1.9	AF	B-52	Astro-compasses
Ling-Temco-Vought	7.6	Navy	—	Operations, Pacific range
	2.2	AF	C-130A	Modifications
	1.0	AF	C-130	Modification and test
	3.0	Navy	—	Atlantic range support
	8.6	NASA	Scout	Production
Lockheed Aircraft	3.0	Army	Nike-Zeus	Radar transmitter
	11.3	AF	—	Satellite production
	3.7	AF	—	Tool modernization
	43.9	AF	Agena	Production
	1.7	Navy	Polaris	Static test vehicles
	1.4	Navy	—	Hydrophone array
	1.3	AF	—	Satellite support
	7.4	Navy	Polaris	Advanced motors
	4.5	Navy	Polaris	Repair parts
	4.2	AF	C-140	Seven aircraft
	176.8	Navy	Polaris	Continue R & D
	22.9	Navy	Polaris	Engineering services
	1.3	AF	Classified	Classified
	7.4	Navy	P2V	Julie-Jezebel
Marquardt Corp.	2.4	AF	—	Research, high mach number ramjet type engines
Martin-Marietta	10.9	AF	Titan II	R & D and testing
Minneapolis-Honeywell	1.5	Navy	—	Signal converters
Mite Corp.	1.9	Navy	—	Airborne teletype
Mitre Corp.	8.0	AF	—	Systems engineering
Morrison-Knudsen & Paul Hardeman	7.8	AF	Titan	Little Rock missile site
Motec Industries	1.4	—	—	Airborne and AGE
North American Aviation	8.0	Navy	—	Nav systems
	3.5	AF	Hound Dog	Autonavigators
	1.3	Navy	Jato	Rocket motors
	1.7	Navy	Polaris	Nav systems
Northrop Corp.	1.3	Navy	—	Logistics engineering
	24.0	AF	T-38A	Jet trainers
Philco Corp.	2.0	Navy	—	Target detecting devices
RCA	9.0	AF	—	Missile track radar
	9.0	Army	PRC-25	Transistor walkie-talkie
Raytheon Co.	1.4	AF	—	Bomb/nav parts
	3.2	Navy	—	Airsearch radar
	5.1	Navy	Polaris	R & D
	9.4	Army	Hawk	Service and data
Serv-Air, Inc.	5.2	AF	—	Operations, Vance AFB
Spartan Corp.	6.2	Navy	—	Sonobuoys
Sperry-Rand	2.8	AF	C-135, C-141	Search radar
	1.5	Navy	Polaris	Systems management
	1.5	AF	C-130	Autopilot
	1.0	Navy	Polaris	Nav system alterations
	3.4	Navy	TPS-34	Radar
	6.5	Navy	—	ASW detection system
Sylvania Electric	1.5	Navy	—	R & D, com equipment
	2.3	AF	—	Magnetrons, klystrons
Texas Instruments	1.5	Navy	Shrike	Guidance
	1.2	Navy	—	Radar components
Thiokol Chemical	4.0	Navy	Bullpup	Liquid propellant
Thompson Ramo Wooldridge	.8	Gen. Dynam.	Atlas F	Closed circuit TV
	.6	Cubic	—	Computers, Atlantic range
Transport Co. of Texas	12.1	Navy	—	Logistics support
Treadwell Co., M. H.	1.7	Navy	Polaris	Electrolytic generators
United Aircraft	1.7	AF	—	Prop overhaul
	27.8	Navy	J52	Engines for AF
	2.8	Navy	J60	Engines for trainers
	1.8	Navy	J60	Engines for AF
	1.8	Navy	TF33	Engines
Varian Associates	1.4	AF	—	Klystrons
Western Electric	20.4	Army	Nike Hercules	Ground equipment
	171.8	Army	Nike Zeus	Continue development
	1.5	Army	Nike Hercules	Production
	1.5	Army	Nike Ajax	Documentation
Western Gear	5.0	Martin	Titan II	Silo shock systems
Westinghouse Electric	1.9	Navy	Polaris	R & D
	10.9	Navy	—	R & D, nuclear propulsion
	1.8	Navy	Polaris	Recorder systems
	16.8	Navy	—	Sub reactor components
	1.2	Navy	Polaris	Recorder systems
	1.0	NASA	—	Arc heater

THE COVER STORY



by John P. Kushnerick
Managing Editor

A lot of companies depend too much on military work.

One weapon system in 15 years is not good enough.

Fred Smith runs the AF. My attention is directed up.

EXCLUSIVE INTERVIEW WITH . . . .

The ZUCKERT-LEMAY MANAGEMENT TEAM

► "We talk about trouble, mostly." That's the way Gen. Curtis E. LeMay, Air Force's top military manager, describes his daily meetings with Eugene M. Zuckert, Air Force's top civilian manager.

At 0845 sharp, the General strides, behind a cigar, into the Secretary's office, whips out his "problem book," and for 15 min. Air Forces' most intimate family problems bounce around room 871 in the E-ring fourth floor.

LeMay meets his own staff once a week. Sees the Vice Chief two to three times daily and hears from the top-policy making Air Force council twice a week. His meetings with the Secretary may take the form of relaying the findings of the staff, it may be a broad "bringing up to date," or it may be a discussion of Air Forces' greatest problem, "technical manpower." But when the two part company, the wheels of a smooth management organization will bring swift results.

LeMay will dump Air Force operating problems in the lap of his Vice Chief of Staff, Gen. Fred H. Smith, Jr. "He runs the Air Force," says LeMay. "I've delegated that responsibility to him. He works down, and I work up." Problems of policy will be handled by LeMay and his Air Staff or Air Council.

Secretary Zuckert is similarly selective of the problems he handles personally. Under the glass on his desk is a list of troubles on which he wants to concentrate. This list is there as a constant reminder. It includes: Guidelines for the Fiscal '63 Budget; Control Procedures for Priority Projects; The Air Force Reorganization; Army Cooperation with TAC for Close Air Support. There are about 20 problems in all.

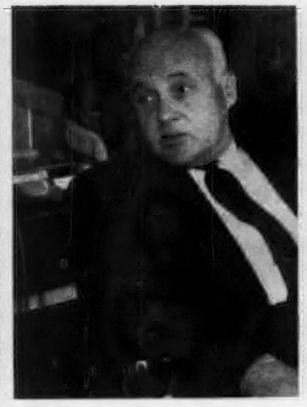
Secretary Zuckert says, "this (defensive management) is just as important as offensive management. It is wrong, but it is the basic concept of military management."

LeMay and Zuckert have a high

A revolution in management occurred in Air Force during 1961. The upheaval was not easy. But, the need for speed in weapon system acquisition meant the two-headed monster of AMC and ARDC had to die.

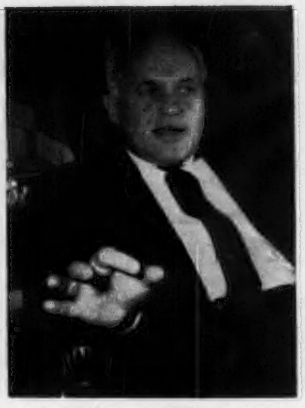
New men and new systems came to the forefront. Quartered in Pentagon's "brass ring" at the apex of the new management look, is the unlikely team of an easy-to-talk-to civilian, and a

If Curt were in business they'd put up a statue . . .



Management is people, not a system of charts . . . .

We make mistakes, but the horror cases are obscure.



Our space program is OK. Dyna-Soar gets '63 funds.

regard for one another. They form what many call AF's management team. "If Curt were in the business world they would put up a statue of him. He is perfect for the times; we have a unique relationship," the Secretary says in heaping praise on his top general.

LeMay is less free with his words. He is a master of the understatement, "the Secretary and I see eye-to-eye on most things—we don't have too many arguments."

What's Wrong — Zuckert and LeMay manage a $20 billion enterprise. It's big, and lot of things go wrong.

"The horror cases are obscure . . . with a $20 billion establishment we must be allowed a few mistakes," says the civilian chief.

LeMay comes straight to the point. "What's wrong is too many people want an arsenal concept, I have always contended we don't need it; I still think so."

"We rely too much on CPFF. This is incentive in reverse. The more these companies spend the more they make . . . we need to develop a new system of incentives."

The Biggest Problem—On one thing Zuckert and LeMay sing a duet in flawless harmony, "People are our biggest problem . . . getting, training, and retraining good people."

Air Force indeed needs good technical people. It is not only operating the most complex weapons we have ever known, it is managing their entire life span from design, thru development and deployment.

Sect. Zuckert tells of a General who once said to him, "I didn't get in this outfit to solve these kinds of problems (management), I got in to fly." He adds, "we don't have people like that around now."

The kind of people Zuckert "has around" are General Bernard Schriever, Commander AFSC, ". . . brilliant." General Fredric H. Smith Jr., Vice Chief of Staff ". . . tops in administration." General Walter C. Sweeney, Commander TAC ". . . he'll do for TAC what LeMay did for SAC." Lt. General Edward J. Timberlake, DCS Personnel, ". . . he'll get us the kind of people we need."

These are just a few of the new breed of management minded generals serving in top Air Force posts.

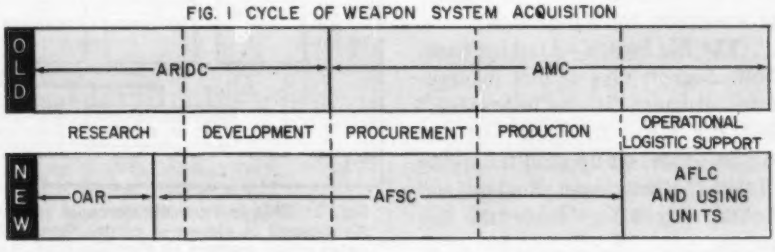
Change of Pace—Air Force has undergone a management revolution since the Zuckert-LeMay team came in. They didn't instigate all of the changes, but they put a lot of horse power behind the whole concept of change.

LeMay says "the biggest change has been one of pace. It used to be one of leisure, now it is one of emergency. To bring one weapon system through full development in 15 years used to be a good record . . . not any more."

What has changed the whole concept of military management is the rampaging pace of technology. In the past it was considered a necessity to conceive, build, test, assemble, and deploy weapons in cau-

tough colonel-eating General. This article is a focus on the men and the management systems they will use to reshape the AF.

FIG. I CYCLE OF WEAPON SYSTEM ACQUISITION



ZUCKERT-LEMAY TEAM
. . . continued

tious step - at - a - time progression. This was to minimize risk and reduce the cost of failures.

The management structure that is Air Force today got its biggest boost in 1954 when the inadequacy of the time honored approach to weapons development became clearly apparent. Dr. John von Neumann, heading a special investigative committee advised that the development of the ICBM proceed "with all stops pulled." Von Neumann advocated upheaval in management. The aim was to compress to a minimum the lead time in weapons development. There were three specific suggestions:

- Let the Air Research and Development Commands' Ballistic (BMD) have full responsibility for design, development, production and deployment of the ICBM.
- Bring in the top research and industrial firms to work with Air Force as a management team.
- Adopt a radical management called "concurrency." In this approach the step-by-step procedure would be abandoned in favor of simultaneous development, test and production of the weapon system and its support and launch complex.

BMD was given unprecedented authority, as a semi-autonomous agency, to push the ICBM on a day to day basis. The object was to bypass the inevitable delays in the decision-making machinery of a huge establishment. The upsurgence of BMD and its parent ARDC eventually broke the back of the Air Material Command (AMC), which at that time was trying to manage procurement and production.

The Big Switch—Looking back, Sect. Zuckert says of that management structure "it was impossible." But Air Force struggled with the ARDC-AMC set up until the spring of 1961, when under Zuckert and LeMay Air Force made the big switch.

What Air Force has today is not a Zuckert-LeMay system. It is the result of a painstaking two year study of systems management, and the speculation that Air Force would receive a military mission in space.

Every major weapon system which Air Force is funding today is simultaneously in development and production. In most cases operational testing and site activation are also proceeding at a rapid pace. Who should have responsibility for these system? The developer (ARDC) the producer (AMC) or the user (operating commands)?

To make the system work at all ARDC was slowly taking away many of AMC's functions. It eventually directed practically all procurement and contracting. The amount of cooperation and interrelationship between AMC and ARDC became so complex as to make it impossible to identify, define, and assign responsibility. (See Fig. 1.).

Field Management — In the spring of 1961 Air Force set up an Air Force Systems Command (AFSC), and Air Force Logistics Command (AFLC), and an Office of Aerospace Research (OAR).

The whole cycle of weapon system acquisition is now under a single manager, AFSC. This command is doing practically everything done by ARDC in the past, and has taken over the management of production, procurement, and site activation which was once an AMC function.

OAR has been given separate status to insure that research people are not overwhelmed with the pressure of making workable systems.

Staff Management—That is the organization that Zuckert and LeMay have in the field to keep the machinery turning.

Closer to home, the Air Staff, the key people that sit close to the Secretary and Chief of Staff, have also been shaken up. (See Fig. 2.) And Lt. General Mark G. Bradley, Jr., emerges as one of the most influential figures. As Deputy Chief of Staff for Systems and Logistics he has been given control over operations that were previously conducted in two different offices. General Bradley has cleaned up "in house" management of Air Force with his "Project Moneytree," an AF-wide conservation program he concocted while droning cross-country at the controls of a C-54.

Eleven Priority Projects — To speed the acquisition of key weapon

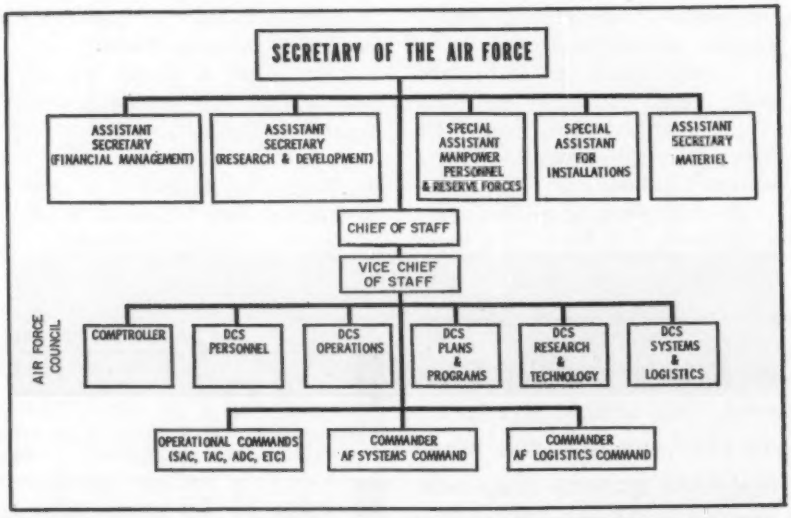


Fig. 2. This is how Air Force is now lined up for weapon system acquisition. Air Council is shown in color. Gen. LeMay as top military man works up, delegates other matters to Vice Chief of Staff Gen. Fred H. Smith, Jr.

systems, several System Staff Offices (SYSTO's) have been established. Eleven high priority systems are called "Designated Systems." They are: Atlas, Titan, Minuteman, B-70, SACCS, GAM-87, Dyna-Soar, Midas, Saint, Discoverer, Big Boosters. About 50 other SYSTO's exist to supply the Air Staff data on the non-designated systems. All of the Designated Systems will soon be using PERT II to aid their development.

Each SYSTO is headed by a key Air Force Officer. The SYSTO office is not a manager. But for getting decision-making information to the top, he becomes the focal point.

Secretary Zuckert says "this man is a walking information file. He has to know everything there is to know about his specific system—and he has to know it NOW."

The SYSTO chairs the Air Staff Working Group and has the unpleasant task of prodding LeMay's Air Staff to action. He keeps close liaison with Headquarters AFSC and with the System Program Director (SPD), who is the kingpin in the field organization, and is the actual manager of systems acquisition. SPD is the focal point for Air Force dealings with industry.

Red Line of Decision—Using SYSTO's Sect. Zuckert has a direct line to all his priority projects and can summon the Air Staff for advice or action through what he calls "the redline process." (See Fig. 3.)

This is how Zuckert's "redline" works. The System Program Director in AFSC, who is the key man in the field, might spot serious trouble on a "Designated Project." He is the judge of whether the problem is serious enough to be "redlined." If he decides "yes" the matter goes straight to Zuckert's attention to be resolved. After consultation with Gen. LeMay, the problem may be judged serious enough for the advice of Sec. Def. McNamara. Using the "red line," vital problems receive the equivalent of corporate attention in the Systems Review Board, and the Designated Systems Management Group (DSMG). Secretary Zuckert as chairman of DSMG, makes all final decisions on "redline problems." See Table I for full DSMG membership.

Package Program—Now at the apex of this new AF management concept sits the Zuckert-LeMay team. At the base or at the working level sits the man who can make the difference between timely, economical weapon acquisition and late, expensive reworks. He is the Systems Program Director (SPD) discussed earlier.

A key weapon is SPD's arsenal of effective management is the System Package Program. This document reflects what resources, guidance manpower, money, and actions are necessary for any weapon. It is the basic tool for planning and implementing weapons acquisition.

It is with the total Air Force set of System Program Packages that Zuckert and LeMay are now "rassling," in the words of the General.

Will industry have benefit of this data for its own planning information? Secretary Zuckert says, "Some already have it; the primes help us develop these figures. Industry must have a clear picture of our long-range budgeting. But how much we can tell, and who we can tell is a big problem at the moment."

Commenting on the fiscal '62 budget and the recent pronouncement by Sec. Def. McNamara that the additional B-70 funds would not be spent, Zuckert shrugged casually "you can't win 'em all." In sharp contrast LeMay says seriously and professionally, "the fiscal '62 program is still as originally scheduled, and our fiscal '63 program includes B-70 funds.

✦

TABLE I

DSMG MEMBERSHIP
(Designated Systems Management Group)

1. Secretary of Air Force (Chairman)
2. Chief of Staff
3. Vice Chief of Staff
4. All Assistant Secretaries
5. The General Counsel
6. DCS Operations
7. DCS Research & Technology
8. DCS Systems & Logistics
9. The Comptroller
10. Commander AFSC
11. Director Office of Missile & Satellite Systems
12. Chairman, Systems Review Board
13. Secretary DSMG and SRB.

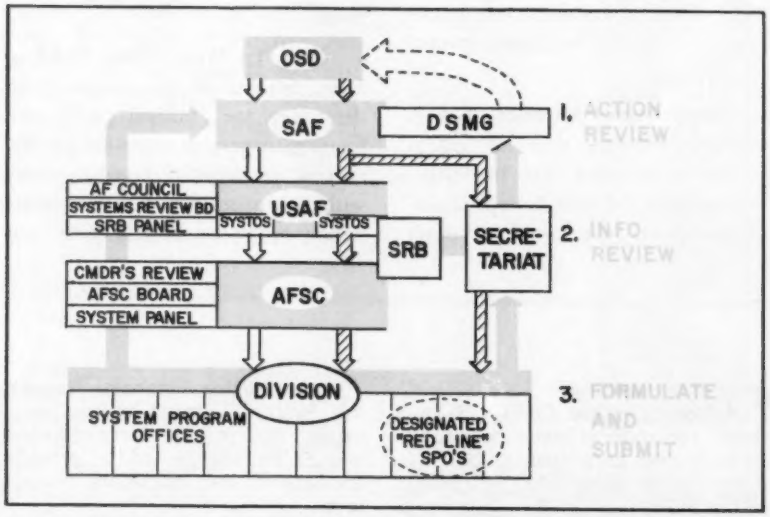


Fig. 3. Air Force has labeled eleven projects as "Designated Systems." They get special attention. On critically urgent matters the "red line" decision is effected. Problems go straight to Sec AF or SecDef.

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A big budget, big plans, and big management problems sum up the NASA situation. But NASA is doing something about its problems. It has realigned its chain of responsibility and has laid detailed plans for the use of PERT in its key projects. HERE ARE THE DETAILS ON . . .

NASA's Plans For PERT

by Tom Mac New, Editor

► With the recent reorganization of NASA management responsibilities and the use of PERT (Program Evaluation and Reporting Technique), NASA has taken the first steps to establish a strong efficient management of its many projects. Primarily, to get new projects like Apollo moving at a rapid and reliable pace, NASA is pinning great hopes on its version of the management reporting technique.

Giving credit where due, the civilian space agency frankly admits borrowing the Navy-developed system. NASA says that PERT has an advantage over most other systems. The advantage comes in the form of getting more vital information, quicker and easier, in a readily useable form.

NASA vs Navy PERT—There's a major change in the NASA system. A single time-estimate is used rather than the Navy's three time-estimate plot. Other than that, there are only minor changes. As NASA works more closely with the system, it certainly has intentions to refine the technique toward its own goals.

Don't Expect Miracles—NASA cautions industry that its system is not a panacea for ineffective management. If you have a chain-of-command type problem, don't expect PERT to solve it. PERT might point out the problem but remember that the program is only as good as the initial data reporting. PERT doesn't show up "lies" until after the fact.

The Office of Programs stresses that PERT should not be thought of as "management by that fast, dumb, obedient servant—the computer."

How To Work With PERT—Basic feature of the system is to determine the "critical path" and focus management attention on the current or potential problem areas within a project. Caution! Preoccupation with the critical path can

NASA Management Tools

• Project Development Plans (PDP)—the key to a summary level network. This plan will produce the basis for development schedules, budget breakdowns, and subsequent financial and progress reporting.

• Agency - Wide Coding Structure—for uniform status reporting by all project participants. Usually comes into being after approval of the PDP.

• Contractor Financial Reporting System — must follow basic project matrix. Line items reported should be segmented to provide an easy fit into summary project level.

lead to complacency in managing other parts of the project. Thus, the requirement for establishing schedules for and monitoring the accomplishment of tasks not on the critical path still exists and must be effectively executed. Otherwise, the system can lead to ill control and poor use of resources.

Networks used in the NASA-PERT system must be set up and maintained by competent technical review.

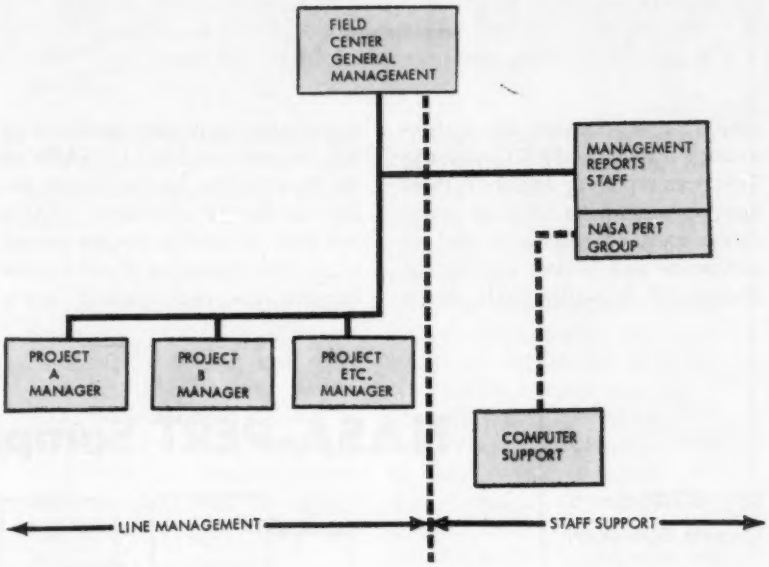
Achieving this objective will require the establishment, development and refinement of certain management and reporting mechanisms. These are necessary to provide a framework within which it will be possible to systemize the time-resource relationship. These systems include such items as Project Development Plans, an Agency-Wide Coding Structure, and a Contractor Financial Status Reporting technique. It is too early to tell whether the establishment of a literal relationship between the time and resources factors, at the most detailed level of project planning and control, is feasible in terms of cost.

There have been many efforts, both inside and outside the government, to furnish updated cost prediction in parallel with time forecasts. The Office of the Assistant Director for Management Reports, NASA headquarters, is keeping abreast of developments in this area with the ultimate objective of prescribing a feasible cost-time correlation system for NASA-PERT.

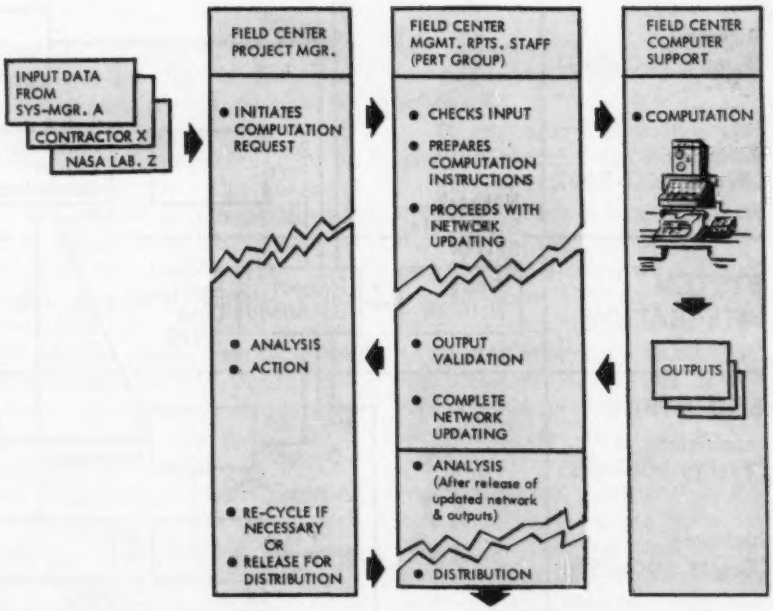
Cost vs. Funding—Recent, suc-

- Requests for Contract Proposals (RFP) — initial step in contracting process. Lays basic groundwork for integrated technical - financial planning, control, and status reporting.

FIELD CENTER ORGANIZATION



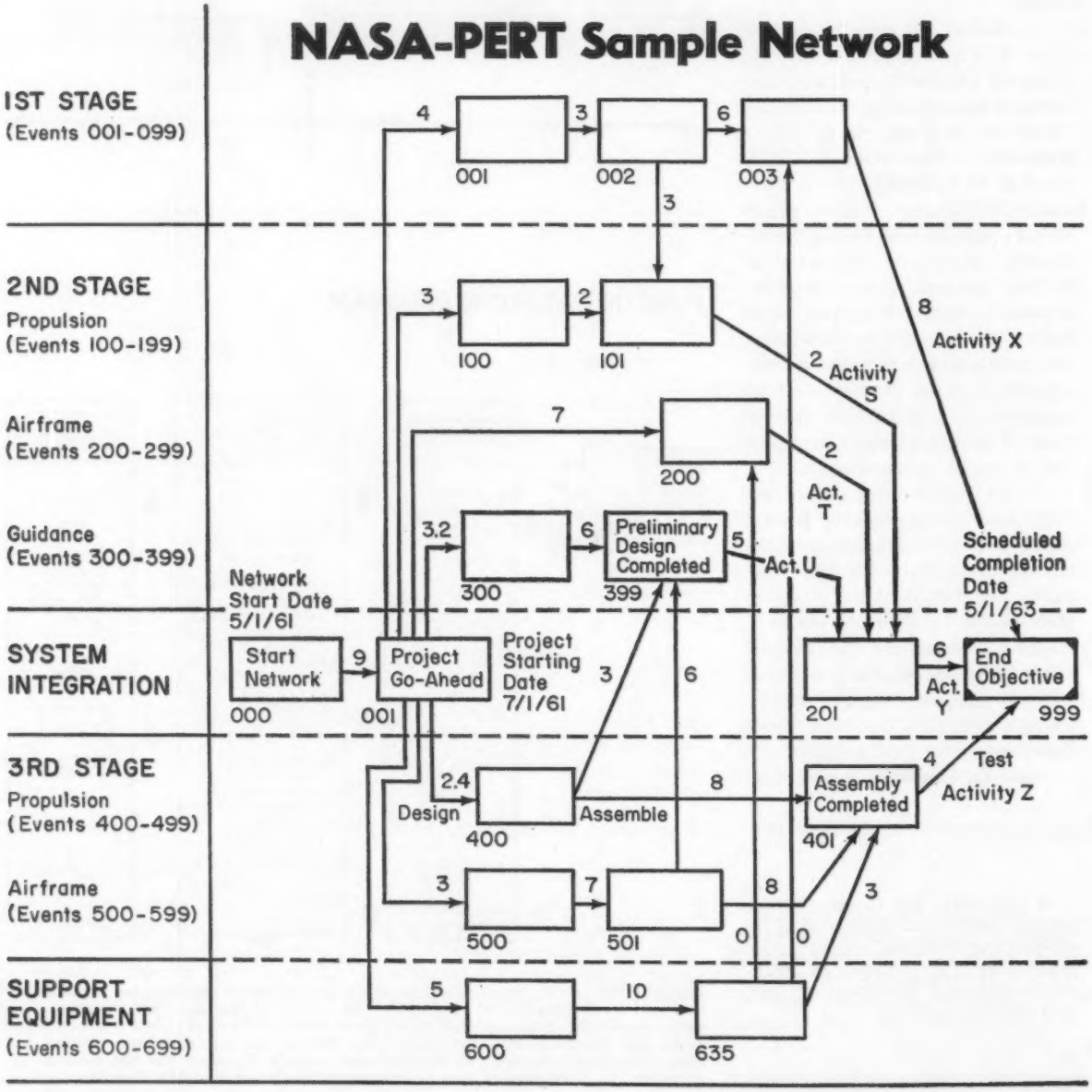
FUNCTIONAL FLOW DIAGRAM



Typical Field Center Organization portrays the elements required for implementation and administration of NASA-PERT as a part of management reporting. The basic capabilities required exist currently in most NASA field centers but in many cases are splintered and not centralized. Unless the organizational entities and their respective functions are well defined, smooth channels will not exist to accomplish the rapid flow of data envisioned in the functional flow diagram.

cessful applications of the cost-resources feature to PERT networks have been reported. However, these only prove that the rules for application must be specific to the organization and project making the attempt. It is hardly likely that a universally applicable methodology will become available to NASA as the result of the specific studies being conducted elsewhere. NASA will have to develop its own system.

A clear distinction must be made between the two financial terms "cost" and "funding." For PERT purposes "cost" refers to the use of resources, i. e., dollars, manpower, material, etc., whether historical or predicted. "Funding" is the term used to describe the process of providing resources. For example, if a



valid time-cost relationship is worked out for a project, and the prediction is made that a particular activity because of a time slippage will require X dollars to complete instead of Y dollars, the amount of X dollars is the new predicted cost. A determination then has to be made as to whether resources allocations within the project will be shifted or whether additional resources will be added to the project to "fund" the new cost requirement for the activity.

Major NASA projects may contain several thousand or more events and activities in their detailed PERT networks. If each of these several thousand activities, measured in time by the beginning and ending event, were also a cost account in the financial system for the project, a direct one-to-two relationship would exist for time and cost measurement and prediction. Assuming a linear relationship between the two factors, it would be relatively easy to parallel cost status output with time outputs. However, the accounting systems at NASA Field Centers and most contractors currently do not provide sufficient machine processing capacity to accommodate this detailed level of cost accounting. Therefore, initially the time-cost relationship in NASA-PERT will have to be established at a more summary level such as major task or subsystem. However, at least one large aerospace contractor has provided sufficient machine processing and is achieving successful correlation of costs using the basic PERT technique.

New Slant Needed—To establish the time-cost relationship will require rethinking and revamping of certain practices and systems in administrative areas, particularly contract negotiation and administration and financial management (NASA internal and NASA contractors). The basic principle is that these administrative mechanisms must be applied to projects in terms of successively detailed level breakouts of the job to be done. This would include the total project, major systems within total project, subsystems within major systems, tasks within subsystems, subtasks within tasks, and finally activities or series of activities which add up to the tasks or subtasks in the detailed networks. To effectively establish the time-resources relationship, it is necessary to establish such a matrix for the project to allow an upward summarization of detailed network activities to the subtask, task, subsystem, system and finally total project level. The establishment of a coding structure to identify these subdivisions of a project can then furnish the basis for both time and cost reporting.

Application to all projects will not be possible on an immediate time scale for many "practical" reasons.

In general, cost-accounting systems within NASA and within contractor organizations provide good detail by project, within functional departmental subdivisions. For example, within a aerospace company the engineering effort on the project level would most likely be accounted for by government contract. But, the successive subdivisions of the project, in terms of project systems, subsystems, etc., would not be accounted for by the engineering department. Thus, refinement in the cost system cross-cutting functional lines to get at the functional departments' contribution to components of the project is required. Only then will a summarization of the project by task, subsystem and system be possible. This effort will also entail reorientation as well as training of personnel who incur the cost and

NASA-PERT Proposal and Contract Clause

Pending formal revision of NASA Form 229, Sample Request for Proposals, and Part 7, Contract Clauses of the NASA Procurement Regulations, the following statements are provided for interim guidance;

1. **Request for Proposals:** Paragraph A7 of the technical proposal should read as follows:

"A proposed time schedule for performance of the work should be set out by phases or parts of the project, and show interrelationships among phases. This proposed schedule should be supported by an accompanying PERT network, prepared in general conformity with the instruction of the NASA-PERT Handbook.

"Contractors are advised that the successful contractor will be required to implement the NASA-PERT system and report program progress bi-weekly."

2. **Program Progress Reports Clause (NASA PR 7.5028):** This clause should be revised by deleting the present subparagraph (b) and substituting the following:

"The NASA-PERT system shall be implemented and maintained in accordance with the NASA-PERT Handbook, NASA Management Instruction, and such other instructions as may be issued from time to time. The system shall be implemented by a PERT team consisting of representatives of the contractor and of NASA. After implementation, the contractor shall submit bi-weekly reports to the NASA Project Manager and/or Systems Manager, or as otherwise designated by Contracting Officer."

who must identify them within the project matrix.

Illogical Subdivision—Currently, the cost matrices used in contract negotiations both between the government and contractors, and contractors and their subcontractors, do not necessarily follow the logical successive subdivision of the project in terms of systems, subsystems, tasks, etc. Also these matrices have not always been retained as a base point for later administration of the contract or subcontracts. This practice must be modified to establish time-resources correlation. The matrix used in negotiations must be the universal project management matrix to be used also for later contract administration. Financial reporting must also be on the basis of the matrix used in original project setup and contract negotiation.

GLOSSARY

ACTIVITY—An event is separated from other events by activities. An activity is a time-consuming element in the development process. It is represented on a network by an arrow. An activity cannot be started until its preceding event has been accomplished. A succeeding event to an activity cannot be accomplished until the activity is complete.

ACTIVITY TIME—Estimate of the time necessary to complete an activity in a specified manner. This time is specified in weeks and tenths of weeks.

CRITICAL PATH — Particular sequence of activities in a network that comprise the most rigorous time constraint in the accomplishment of the end event. The path with the smallest amount of positive slack or largest amount of negative slack.

EVENT — A meaningful specified accomplishment in the plan recognizable as a particular instant in time. (The boxes on a network)

FLIGHT MISSION (OR MISSION) — Within a project, the specific scientific or technical objective(s) to be accomplished by a given launching of a space vehicle or launch vehicle.

MANAGER—Individual in the field center who is assigned the operational responsibility for executing to completion the development and operation of a project, a system, or a flight mission. (Project Manager, System Manager, Flight Mission Manager).

NEGATIVE SLACK — Amount of time which is **not** available to perform the series of activities in a particular slack-path and still meet the required completion date.

NETWORK — Sequenced diagrammatic representation of events and activities.

POSITIVE SLACK — Amount of additional time which is available to perform the series of activities in a particular slack-path and still meet the required completion date.

PRECEDING EVENT—See **ACTIVITY.**

PROGRAM—A related series of undertakings which are funded for the most part from NASA's Research and Development appropriation, which continues over a period of time (normally years), and which are designed to accomplish a broad scientific or technical goal in the NASA long-range plan.

PROGRAM CHIEF—The staff individual in Headquarters to whom a Headquarters Program Director has assigned cognizance over a program.

PROJECT—Within a program, an undertaking with a scheduled beginning and ending, which normally involves one of the following primary purposes:

- Design, development, and demonstration of major advanced hardware items;
- Design, construction and operation of a new launch vehicle (and associated spacecraft and ground support) during its research and development phase; or
- Construction and operation of one or more space vehicles and necessary ground support in order to accomplish a scientific or technical objective in space.

SUCCEEDING EVENT—See **ACTIVITY.**

SYSTEM—One of the principal functioning entities comprising the project hardware within a project or flight mission. The terminology may vary to suit a particular project. Ordinarily, a "system" is the first major subdivision of project work. (Similarly, a "subsystem" is a functional entity with a system.)

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OBJECTIVE:
· Expand new product development and related research capability.
METHOD:
· Additional experienced Research & Development Engineers

Just a few words, but they tell our story. The Military Aircraft Systems Division at Wichita is vigorously expanding efforts in research and new product development. Right now our engineers are advancing the state of the art in Variable Sweep Wing technology; engaged in design of land and carrier-based V/STOL vehicles; conducting studies and tests in operation of high-performance aircraft at Low Level; and working extensively in the areas of Fire Control, Bombing, Navigation, Guidance, Reconnaissance and Surveillance systems. These are only a few of the challenging assignments that await the Experienced research engineer at MASD. • We have the assignments; we have one of the most modern, up-to-date lab and test facilities in the industry; and we have a professional environment that will appeal to the most experienced engineer. To qualify, you should have an engineering degree—preferably an advanced degree—and research and development experience in aircraft, missiles or related areas. For specific information regarding assignments, facilities and living conditions in Wichita, write in strict confidence to Mr. Melvin Vobach, Dept. OBD, The Boeing Company, Military Aircraft Systems Division, Wichita Branch, Wichita 1, Kansas.

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An Equal Opportunity Employer

Army invites top-management officials from Bendix, GE, Martin and RCA to discuss implementation of value analysis programs. Presentations describe techniques found successful in: ■ Conducting seminars. ■ Organizing value programs. ■ Training specialists. ■ Promoting value-analysis communications. ■ Integrating value analysis into procurement.

ARMY ACCENTS VALUE ANALYSIS

by **S. Peter Kaprielyan,** Technical Editor

► Waging war against the soaring cost of defense is becoming a grim preoccupation both for the Military and the industry; in the light of the prolonged Cold War it must become a way of life.

These were the overtones of Army's Value Analysis Seminar held recently in the Pentagon. The seminar was sponsored by the Deputy Chief of Staff for Logistics, Lt. Gen. Robert W. Colglazier and Chief of R & D, Lt. Gen. Arthur G. Trudeau. Participants included Assistant Secretaries of the Army, Dr. Finn J. Larsen (R & D) and Paul R. Ignatius (Installations and Logistics), as well as top-management representatives from the industry.

Presentations made by industry representatives covered the following key facets of value analysis efforts currently in effect.

What and Why of Value Analysis

Cost reduction efforts in the defense industry today are being seriously hampered by the lack of a true definition of Value Analysis. We all have our own opinions of what it is. Because of this, very few companies have a full value analysis program. We don't want to be left out, so we hang this name on whatever we can find in our organization that has a cost reduction assignment and leave it there.

This often creates trouble in a company by spotlighting a particular group as the only place where savings can be made.

Objective goals must be established for all divisions and departments in the plant, with efforts and results coordinated by one responsible group. These goals must be obtainable and understood by all concerned. When we say reduce your cost by 25 per cent, we must be sure we clearly state 25 per cent of what.

Value Analysis is the analysis of value. Total value is the total cost of doing business—not just the cost of hardware. It is the search for true value in everything we do, from the sweeper to the president, from the space we occupy to the paper we use. If we identify value analysis with anything less than this, we will not get full value. The missing 25 per cent, the fourth missile for the price of three, lies here. Management with all its tricks, brains and power has never been able to get that last 25 per cent because they cannot do it alone. This is no criticism of management—it is a simple fact that no management can create an atmosphere where every

VALUE ANALYSIS DEFINITION
(Army Regulations No. 700-47)

Value analysis is the broad term used to identify all actions which identify and eliminate unnecessary cost in the design, development, and procurement of Army materiel without sacrificing essential quality or performance. It is a functionally oriented, planned effort by trained personnel using specific techniques. It encompasses activities variously referred to as "value improvement" and value engineering.

Value analysis seminar panel included (from left): Lt. Col. Dichtenmueller, Office Chief of Ordnance; G. J. Parker, The Martin Co.; I. K. Kessler, RCA; Brig. Gen. Ryan (moderator), Office Chief of R & D; M. F. McCammon, The Bendix Corp.; L. D. Miles, GE; and Lt. Col. Hughes, Chief Item Engineering Branch, Standards Div., ODCSLOG.

person in the organization truly has an incentive to do his very best.

The only way the average person will do anything voluntarily—all the time—is for his own self-preservation. This then is our definition of value analysis at Martin-Orlando: the analysis of value—the search for true value in the total cost of doing business. We are dedicated to the proposition that everything we do costs money and that it can be done for less—this makes it everybody's business.

This brings us to the "why" of value analysis. Why should our people want to reduce the cost? What is the motivation?

The simple answer is—to better the nation's chances for survival.

Communicating Value Analysis

To encourage cost-consciousness in employees, you need communication; persuasive, sincere communication that accomplishes four basic objectives. It must:

- Gain attention
- Create interest
- Stimulate desire
- Result in action

Communication program, at Martin-Orlando, is made up of three distinct approaches.

Top-Priority Approach — This action started as a letter from top management and imparted a real sense of urgency to the program.

Our letter, mailed to each employee's home, spelled out purpose, goals, and techniques of value analysis (VA).

Enthusiastic top management support continued; VA quickly became the talk of the plant at staff meetings, planning sessions and conferences. Articles were placed in the Martin-Orlando Management Club Newsletter. The club—an influential group, must be solidly behind a program if it is to succeed.

Seminar Participants From Industry

Dr. A. Hall	Vice President Engineering, The Martin Co.
C. J. Parker	Director Administration Div., Martin-Orlando
R. L. Bidwell	Mgr. Value Analysis Admin., Martin-Orlando
I. K. Kessler	Vice President & Gen. Mgr. Aerospace Comm. & Controls Div. RCA
J. R. McAllister	Purchasing Agent, Aerospace Comm. & Controls Div. RCA
H. J. Morley	Purchasing Agent, Missile & Surface Radar Div. RCA
R. H. Isacs	Vice President Military Relations, The Bendix Corp.
M. F. McCammon	General Manager Eclipse-Pioneer Div., The Bendix Corp.
G. F. Metcalf	Regional Vice President, GE
L. D. Miles	Manager Value Services, GE
J. W. Bryant	Mgr. Cost Impr. & Value Devel. HMED, GE

Another important management medium is our monthly Supervisory Followup Discussion bulletin. This goes to supervisors as a guide for discussions with his people.

Facts-of-Life Appeal—This section of the campaign is based on tough, hard facts.

Man-to-man talk is the ideal communication. That's why we program seminars for a free flow of information. Just a few weeks ago we conducted a five day value analysis seminar for middle management. Vendors, subcontractors and representatives of the military services also attended. The object was twofold: (1) We wanted all our people in attendance to practice the technique of value engineering. (2) We wanted recommendations for reducing costs on specific items of hardware from three of our major projects.

Results were excellent. Total savings of $6 million were recommended. We have conducted very successful seminars with our vendors and subs on both the Pershing and Bullpup projects. Overall cost goals of 30 per cent were established prior to the meeting. In the case of Bullpup, the goal was exceeded since we have reduced overall costs by 31½ per cent in the last nine months. We are now shooting for 40 per cent.

We have also made impressive progress on Pershing even though it has been in R&D. We have reduced the cost of purchased items by 22 per cent. This type of meeting of minds between buyer and seller is our primary form of "facts of life" communication and it is still unequaled in results. Vendor participation is an important phase of our value analysis program.

Even stairways can be used for value orientation. On the risers between the stairs, in our plant, we placed red and white signs imprinted with the basic questions of value analysis:

- What is the item?
- What is the function?
- What does it cost?
- What else would do?
- What does that cost?

Straight, blunt questions, placed in an area where they can't help but be noticed.

On pay envelopes, periodically, we print a straight fact message on the economic need for value analyz-

ing our work. This message is received at the precise time when the reader has his mind on money . . . his own.

Friendly Persuasion — This is phase three of our communications campaign. Because people dislike being constantly bombarded with grim imperatives, we complemented our "facts of life" approach with pleasant, friendly reminders that value analysis is a continuous job. The media we use in this part of the campaign include posters and brief messages in the plant, on the company bus, on coat racks, on time cards, on typewriters, etc.

Lastly, "do-it-yourself" displays are used to familiarize engineers with various machine-finishes and their comparative costs. Here's where engineers actually pick up the examples of different machine-finishes to really "feel" the cost involved. More than any other communication, this display dramatizes the need for more functional design with cost in mind.

Value Analysis

It is RCA's policy to have value analysts report to the purchasing department. Here's why:

- To give the value analysts the proper prestige in the department.
- To better insure that other sections of the purchasing department work and cooperate with the value analysis group.
- To place the value analyst in the most advantageous position to work with other departments within the division.

Value analyst's responsibility is to analyze production parts and materials to effect maximum cost reduction through revisions on parts designed, use of alternate materials, changes in manufacturing methods or modification of sourcing practices.

The value analyst must qualify basically by an engineering education, shop experience, and a knack for getting along with people. His greatest assets, however, are a flexible imagination, initiative, and the ability to sell an idea.

Here's how the value analyst receives his assignments.

Buyer referrals — When the buyer feels that the cost of a part is excessive, he turns the problem over to the value analyst. The Buyer does not usually have the extra time to spend in searching out substitutions or find better ways by working closely with the design group.

New Design Releases—Review of new design releases from the objective view-point of the analyst has its salutary effects. This area, however, is probably the least productive due to limited time allowed from design release to production.

Production Review—Review of equipment in production, in anticipation of repeat business, is another phase of the analyst's job. Here we require close coordination with the marketing department to anticipate repeat business from the information received from the military. This is where the value analyst has the advantage of knowing the equipment and having sufficient time to make a complete review and study with cost-reduction in mind. This area is certainly the most fruitful.

Each division of Defense Electronic Products operates a little differently due to the various equipments they build. Aerospace Communications and Controls Div. has recently changed their value analysis operating policy and permits the value analyst to contact and communicate directly with the vendor rather than deal thru the buyer. This will obtain greater savings. It gives the value analyst the authority to try new ideas with old and new sources and without the delay created by going thru a third party. After completion of his study, the value analyst turns the information over to the buyer for action. Under no circumstances do we permit the value analyst to commit the company. This is solely the buyer's responsibility.

Source Selection — Here the value analyst plays a part in the team effort. He assists the buyer by reviewing the specs with potential sources, revamps tolerances and specs that inflate the price.

Request for bids from sources having the right facilities is an important part of correct buying. The value analyst must be acquainted with the most modern production methods to assist the buyer in choosing sources.

We have had instances where the buyer has been "locked in" to a sole-source condition and was unable to generate competition. In some cases we have referred this problem also to value analysts. They have been able to obtain substitutions, working out the details with the design group involved, and enabled the buyer to establish competition.

The value analyst can also play an important part in the early stages of the development program that is being subcontracted to outside sources. In many instances, smaller or middle-size companies although well talented in engineering, do not have qualified value analysts or production personnel. Where possible we attempt to have our value analysts sit in the design review meeting at the subcontractor's plant to suggest changes for lowering costs.

Another phase where the value analyst can assist the buyer is in negotiating subcontracts. By examining the vendor's method of processing, when a repeat contract is being negotiated, the analyst may suggest improved methods of processing and furnish the buyer with another negotiating point.

Organizing For Value

From a viewpoint of end-product cost, new products are almost totally old. It is a rare development in which the area of total newness comprises more than 10 per cent

of the end product manufacturing cost. Let's set aside the 10 per cent product-cost which will go into new technology and face the task of removing large dollars from the 90 per cent.

Experience has proven that shorter development time in producing reliable developments—economical to manufacture—is limited far more by lack of the new idea than lack of a new material or process.

R & D organizations might then be arranged for searching, locating and providing the necessary new ideas which will reduce costs where they are greatest but utilizing known technology and hardware.

GE has had some astounding results in test cases where one value engineer was assigned to each design engineer. Simpler, more reliable, lower cost solutions to technical problems did forward in a minimum of time. Both engineers stated that they had never worked in such a productive atmosphere.

Value Engineer's Function—Hard-pressed management of R & D work will immediately ask, "What does this value engineer do?" He utilizes his technology to provide to design engineer alternatives of large economic value; he lengthens the design engineer's reach and shortens development time.

But it is asked, "If I want R & D work to go faster, why wouldn't I just hire another engineer? Why would I hire a value engineer?

Why would you hire a metallurgist or vibration specialist to work with the engineer instead of just hiring another engineer? Because you have learned that his knowledge and his approach get the engineer to the better answers sooner.

The value engineer is not a specialist in this sensitive area, but an "extreme generalist." He does not know steels in depth, electronic circuits in depth, vacuum castings in depth or any other specific traditional technology. What he knows and uses in depth is a system for identifying function, for evaluating functions in dollars, and for starting chain of activity which will produce, from vast and diverse resources, the economic solutions of the problem, often "ready to use."

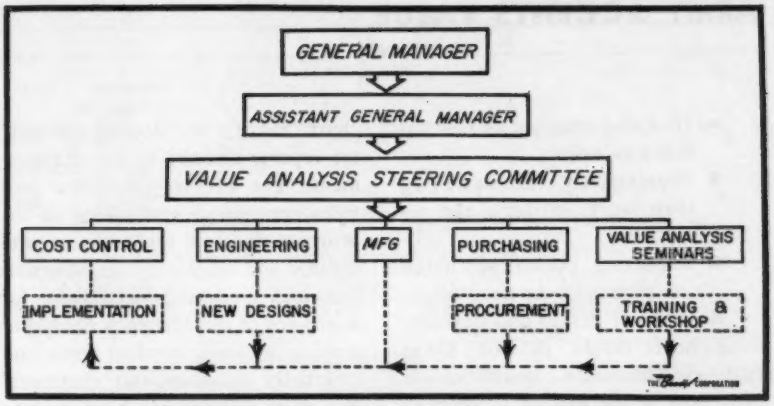

Fig. 1. Value Analysis Organization and Flow Chart

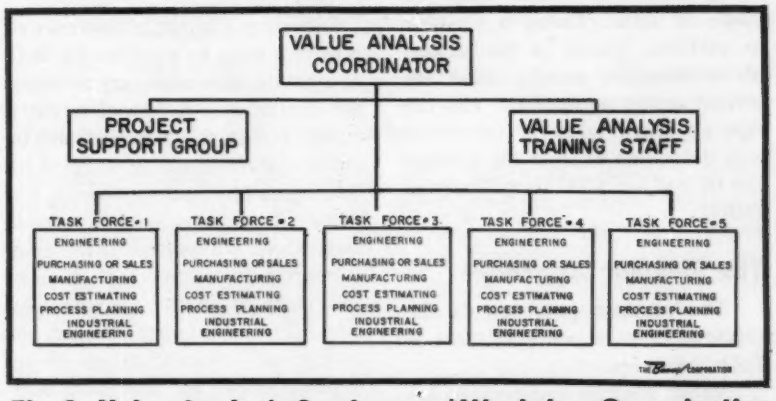

Fig. 2. Value Analysis Seminar and Workshop Organization

Is he a crutch? Is an advanced mathematician a crutch—is a specialist in servo-mechanisms a crutch—or the efficient way to accomplish the objective? Seldom is a large task appropriately accelerated by increasing numbers of workmen using the same tools.

How Many Are Enough?—You might well ask, at this point, "Do you mean that if I am using 500 engineers in R & D work and I want to increase their productivity as you have outlined, I must hire 500 value engineers?

Certainly not.

Select fifty. Make certain that they represent your average pattern of abilities, some being among your most productive men. Have them trained in the technology of value engineering. Assign them to engineers who are responsible for important areas of functional performance. Learn how to integrate their benefits into the organization. Then, on a basis of known performance, "grow" the changes in organization to provide an effective technical and economic development group.

Later, train more value engineers as needed. Meanwhile, provide suitable information to the remainder of the organization so that they will understand the value engineer, his mission, how he goes about his work and how together they can secure better results faster.

Again, the manager's work will be different when he has a suitable number of value engineers. His work must include:

- Planning the economic or cost results expected of each value engineering man or group.
- Providing to them the tools their technology requires.
- Pacing them.

- Directing changes as new influences arise.
- Progressively measuring their work, progress and results.
- Reporting periodically to top management on progress.

Realities of design and development have taught us that lower cost—or increased quantities—is often lost at the first of a group of four or five design and manufacturing decisions which must be made in series. Given a function to perform, except in the newest of technologies, usually there are several design approaches. The design approach taken at this point may determine whether the product can be had for $500 or will require $5000.

The Seminar Approach

The seminar approach is the keystone of value analysis effort at Eclipse-Pioneer.

Value analysis program is implemented through a steering committee comprised of the managers of various divisional functions. The steering committee organizes the seminar, selects participants and a seminar support group. This group receives seminar reports, directs the implementation of the cost-reduction suggestions, and makes value analysis policy decisions. Steering committee is responsible to the general manager of the division.

A two-week seminar is conducted for each group of 35 selected management personnel. These attend one-hr daily indoctrination sessions, each followed by a 1½-hr workshop session on several products. The seminars, we feel, provide both the facility for the rapid training of successive cross-sections of our management personnel, while at the same time successive cross-sections of our product line are subjected to the value analysis scrutiny.

Value Analysis Organization—As reflected, by the organization chart (Fig. 1), the steering committee reports directly to top management. The steering committee provides continuous stimulation of the program by top management and assures the necessary implementation and feed-back—internally for assurance of the efficiency needed to continually lower product costs, and externally to assure our customers that their welfare has been permanently crystallized as a function of Bendix' policy.

Steering committee convenes on a regular basis to promote the flexibility of decision necessary to changing conditions. A formal report is made of each meeting held and indicates future programs planned for training and for special projects. The status of previous seminar recommendations is reported to the committee by the cost-control manager and included in the meeting minutes. The committee decides on policy and implementation of internal publicity for the value analysis program and selects the cross section of personnel for training.

Value analysis training seminars are conducted under the guidance of a value analysis coordinator who establishes seminar schedules. The coordinator's staff prepares the training curriculum, schedules speakers, and compiles blueprints, manufacturing costs and product models for reference by seminar attendees.

All seminar reports are directed to the cost-control manager. Our value analysis efforts comprise two distinct areas of operation. The value analysis group operating within our purchasing organization serves as liaison between our vendors and our engineering and manufacturing organizations. For the application of value analysis techniques at the design stage, task forces for new designs are created under the engineering function of the steering committee.

Seminar Organization — The seminar is conducted under the guidance of the value analysis coordinator (Fig. 2). The regular value analysis staff members who conduct the seminars are not full-time training personnel, but represent a cross section of personnel with prior training in value analysis. Support group consists of recognized company experts whom the seminar teams may call upon as consultants. This support group is variable in its make-up and the talents selected are determined by the products which are the subject of the seminar. We deliberately assign some personnel to each group who do not have experience on the particular product.

The roster of each team is selected by the steering committee and notified in a personal letter from the general manager. In the selection of engineering personnel, the design parameters of the product under consideration become a determining factor.

Prior to the start of the seminar, the industrial engineering organization is charged with providing all necessary blueprints, cost data, engineering specifications, field service reports, operational analysis sheets, time studies, etc., for each team, as well as a sample of each component part and also a model of the completed unit. In brief, by the nature of the team make-up and the materials provided to them, we create an autonomous and self-sufficient group who at the most will require only the advice of consulting specialists before making firm recommendation.

Job Plan Schedule—The seminar Agenda is designed to conform to the six steps of the value analysis job plan (Fig. 3) furnished to each member. The coordinator's staff, who serve as team advisors, constrain the teams to devote their efforts solely to the particular phase of the job plan which has been designated for that day.

To fortify the teams in their efforts we have outside suppliers in attendance during the workshop sessions. These are called in whenever a team desires more information about a new component of which they may have only a cursory knowl-

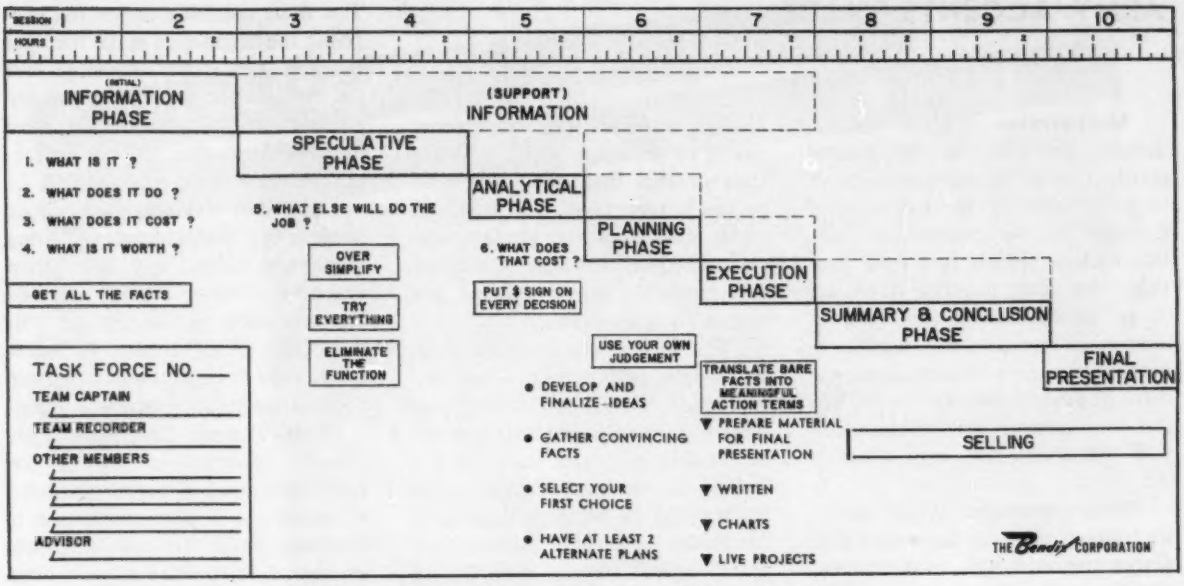

Fig. 3. Value Analysis Job Plan Schedule

edge, or if they desire more information about any supplied item.

On the closing day of the seminar, each team-captain is allowed ten minutes to present the highlights of his team's accomplishments.

Following the presentation, the managers of various functions offer brief remarks on the team's efforts and the merits of the value analysis proposals.

Seminar Follow-Up—Success of the value analysis program depends to a large extent on the implementation of the seminar recommendations and on the follow-up and reporting procedure. At Bendix the implementation of ideas is pursued by the steering committee through the agency of the cost control manager. All seminar reports are forwarded to the cost-control manager who works closely with the director of engineering, to establish a working committee for each specific seminar or product. The function of this working committee is to immediately review seminar reports and determine the implementation program. The working committee is basically comprised of engineering personnel selected by the director of engineering and, as required, purchasing and manufacturing personnel are solicited from respective managers. The working committee convenes immediately upon receipt of the seminar reports and is responsible to the cost control manager.

The working committee meets daily for at least one hour for ten successive days with the objective of completing the investigation needed to incorporate the seminar ideas into the product. The working committee prepares a final report of this investigation and action taken. This is forwarded to general manager, subject to prior review by the steering committee. Cost-control manager advises the value analysis coordinator of the contents of the working committee's report so that he may inform the seminar team members of the status of their suggestions. If the proposals are such that they require reliability or environmental testing, or customer approval, a status report is submitted periodically to the cost-control manager.

One of the means we use to up-date our value analysis seminars is through survey questionnaires. These solicit the feelings of the attendees regarding various aspects of the program as well as the program as a whole. This running commentary is constantly fed back into the program, and can account for the improvement of the training methods which have resulted.

This seminar approach has been so favorably received within the corporation that all of our divisions are undertaking, or revising value analysis programs currently in effect, to the seminar approach.

Distinct benefits are reaped from value analysis seminar efforts. These benefits can be traced at least to five areas.

Training—An awareness is developed in each trainee, of the need for critical thinking even about the most tried and true aspects of his work environment. He is trained to use an organized approach to whatever problem he many encounter. He is instilled with a receptivity to new ideas, and the importance of openmindedness. Having once been impelled to be creative he shall never again be quite the same person.

Communication—Value analysis opens wide the gates to better internal communications of any organization. Team members from widely separated functions become acquainted. The effort brings together the top, intermediate and lower levels of management. Thus, top management is given the opportunity, through mingling with the teams, to make a personal appraisal of individual skills and specialists of whom they may not have been aware. *. . . continued on next page*

Identification—Value analysis, through the talks by the general manager on the necessity to improve products, and by the cost control manager on our competitive position and its related problems, provides the team member a chance to be identified with the top-level people. In addition, the seminar is looked upon as a temporary assignment to general manager's staff. We feel this intimate sort of identification will follow the man back to his job.

Value Assurance—Value analysis training provides assurance that design engineers will, in the future, question more thoroughly each aspect of both the customers' specifications and their own designs. Also, the design engineer now recognizes that his design will be the subject, sooner or later, of a value analysis seminar and he will be anxious in a competitive sense, that as few changes as possible will be forthcoming.

Customer Relations—An active value analysis program assures the customer that everything possible is being done to reduce the price and/or increase the reliability of the products he buys.

Most administrators emphasize the human-relations aspects of their responsibilities, yet they decry the fact that they are able to do little in this particular area. Our feeling is that value analysis provides the forum, in the seminar approach, for interaction of all levels of management.

Training Value Specialists

The value specialist's job, at GE-HMED, is to help other people make good use of value analysis techniques. He must have at least five years experience in engineering, or equivalent experience in manufacturing. He must be personable, well spoken, mature, and be able to disseminate ideas.

Training for the Job—Specific training in Value Analysis is obviously required. The basic phase would be to attend value seminars, then practice and apply the techniques learned there. The value analyst must acquaint himself with the operations of specialty vendors, new materials, prices, and his own organization's services.

The second phase of his training would involve actual product evaluation work, particularly participation in value studies, assisting in training programs as a project leader. In the advance phases of his training he must participate as the leader of a value training program, coordinate the activities of a value study, participate in product-design review during all phases of the product cycle and to develop new methods for the products. The development of a professional value analyst is a never ending job. However, depending upon the initial qualification of an individual, good value analysts can be developed in a minimum of two years.

Value Specialist's Role—The job of the professional value engineer is to identify but not to remove the unnecessary costs himself. Why do unnecessary costs creep into our products in the first place? There are three main reasons:

(1) Lack of time—The engineer doing the job has just so much time and often it is not enough. We do our best with the time we have, then go on to the next job.

(2) Lack of information—It is impossible for everyone to keep abreast of all new developments that could affect costs.

(3) Improper habits and attitudes—Habits can only take us where we were yesterday and they are extremely costly in our business.

Pitfalls To Avoid — Here are some common pitfalls that must be avoided in training value specialists:

Failure to Give Credit—If the engineer or draftsman or whoever is the source of a cost-reduction idea is not given recognition, his co-operation is bound to vanish. The value specialist makes the proposal; the originators make the final decision, hence they should receive the credit when these proposals are successful. This recognition must be in a form that reaches the recipients immediate superior.

One-Shot Training — A single seminar can not achieve everlasting value enthusiasm, any more than one polio shot can achieve everlasting resistance to the disease. Enthusiastic value climate is maintained only through constant booster shots in the form of repeat training.

Half - Hearted Training — Progressive management realizes the vital importance of proper attitudes in the minds of all personnel on a continual basis. To consider such an important function as part time will result in mediocre operations and eventually a mediocre attitude. One acceptable alternate is to periodically hire professional trainers for a seminar, at strategic times in product development and production. There are excellent sources for trainers available today. However, the most effective method is to organize your own full-time, in-house value organization.

Inadequate Tutoring—A poor trainer can generate negative attitudes that will make the creation of good value climate twice as hard. So if you are using your own trainer and own project leaders, select them carefully because that could easily kill all your efforts.

One might ask, at this point, whether there are enough men qualified for all phases of value analyst's job. The honest answer is that usually all the requisite capabilities are not found in one man. The job scope requires that he be both creative and analytic, as well as promotional and educational by nature. This requires, therefore, a search for both types of individuals.

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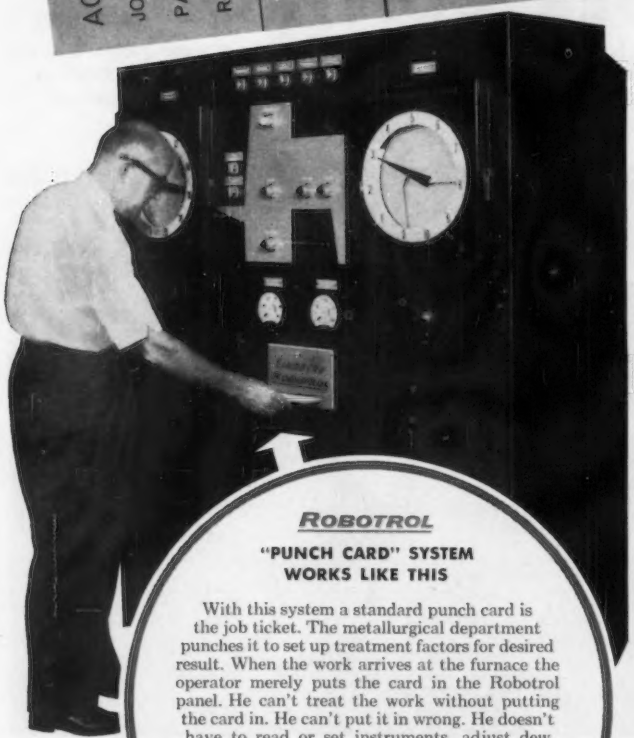
HERE'S A NEW CONCEPT IN HEAT TREATING TECHNIQUE.

AUTOMATIC 'PUNCH CARD' QUALITY CONTROL SYSTEM NOW PERFECTED.



ROBOTROL

"PUNCH CARD" SYSTEM WORKS LIKE THIS

With this system a standard punch card is the job ticket. The metallurgical department punches it to set up treatment factors for desired result. When the work arrives at the furnace the operator merely puts the card in the Robotrol panel. He can't treat the work without putting the card in. He can't put it in wrong. He doesn't have to read or set instruments, adjust dew points, time carburizing and diffusing periods, decide on type and timing of quench. The punch card controls these automatically. It can provide for a variety of operations and required cautionary procedures. As the work moves on and is completed the punch card provides a permanent record of the exact treatment given it.

Provides exact record of metallurgical treatment on every job

System completely eliminates factor of furnace operator error

LINDBERG ROBOTROL

Guarantees you precise uniformity and quality in heat treating

Introduced at the recent ASM Show at Detroit, this new Lindberg Robotrol automatic quality control system has been in development for more than five years. With this punch card system pyrometers, timers, atmosphere control instruments and all the factors on which metallurgical results are dependent are set up and automatically controlled. It is practically impossible for the furnace operator to treat the work improperly.

The punch card also provides an exact record of the treatment given each job. You know exactly what happened.

The Robotrol system is extremely flexible and can be adapted to any kind of heat treating cycle. For full information get in touch with your local Lindberg Field Representative (see your classified phone book) or write us direct.

LINDBERG ENGINEERING COMPANY
2473 West Hubbard Street, Chicago 12, Illinois

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, Spain, Switzerland and West Germany.

Engineering departments work daily to create and refine designs. But, each little "refinement" can throw a project into turmoil if it is not handled properly. Every company is eventually faced with the problem of design-change-control. Here is what management at GE-MSVD is doing to guide and control the changes Engineering would like to make to its designs.

KEEPING DESIGN CHANGES UNDER CONTROL

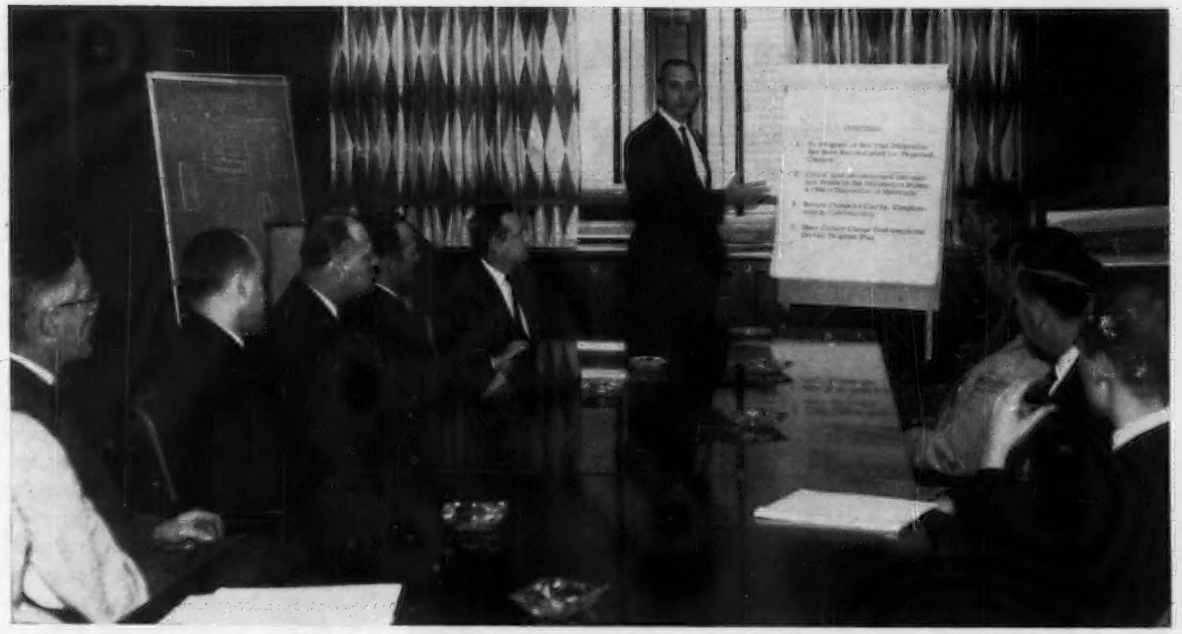
by S. Popovich, Manager
Design-Change Control, GE-MSVD

► Good design-change control is getting more and more significant. Developers of aerospace systems and subsystems sooner or later find themselves struggling with this problem. To keep each design-change action straight, and to make certain that the right hand knows what the left hand is doing, good control is a must.

The problem is complicated by tight schedules and the development engineer's dislike for being held to a formalized system.

But even in development work, a number of things have made it necessary to change from an informal control system to a change system like that expected of a production program. These forces include:

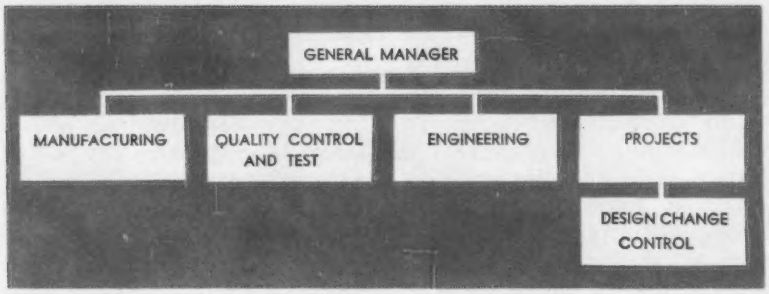
- Elimination of a mock-up, or a schedule where the mock-up is the first unit shipped.
- Compressed time schedules.
- Variations in development model designs and this flexibility necessary to make customer requested changes.
- Large numbers of development units.
- Complexity of the hardware and an evolution of the specialized area such as:
  a. Structures
  b. Guidance
  c. Instrumentation
  d. Communications
  e. Life Support Systems
  f. Ground Equipment
  g. Nuclear Ordnance
  h. Antenna
  i. etc.
- Complexity of the system where ground support and ground operating equipment are an integral part of the overall system design.



Design Change Control Boards have been appointed for each of GE-MSVD's major projects. Each board meets daily. Then a highly organized communications system gets the approved changes to every affected department within hours. Here, S. Popovich of the Design Change Control Office talks with Chairmen from Skybolt, Nike-Zeus, Advent, Nimbus, and OAO.

RIGHT: Fig. 1. To best serve GE in aerospace, the design change control function is assigned to the Projects Office. At MSVD, project managers have overall responsibility for a program.

◀ Facsimile transmitter used to speed change data to and from GE's nationwide network of plants. Author Popovich gets last minute look at Re-entry Vehicle data being sent to Burlington, Vt., from Change Headquarters in Phila.



- Field use of development equipment and the need for logistic support and instructions for this type of hardware.
- Many retrofits of development hardware in the field.

Problems At MSVD — As it emerged from the paper-study stage to the hardware stage of its first re-entry vehicle, General Electric-MSVD found itself struggling with the problem of Design Change Control.

In the main, the problem seemed to be a lack of proper overall integration and organization. Often changes were made in one area without other affected operations being aware of the change. Clearly defined standards were not available to the engineer to assist him in preparing a change. No plan existed for setting the introduction for a change and for making a disposition of existing materials.

To overcome these ills a Design Change Control office was established. Its purpose was to provide Design Change Control guidance for the entire MSVD. To best serve all operations the function was attached to the Projects Operation (Fig. 1).

This organizational structure achieved a department approach to the problem. At GE-MSVD, the Project Manager has overall program responsibility. The Design Change Control Office is attached to the projects operation to represent the Project Manager in change activities. To review any proposed design change, a Design Change Board has been formed. It consists of a cross section of qualified representatives from all major Engineering, Quality Control, Test, Project and Manufacturing areas. The Chairman for the Board is assigned to the Design Change Control Office.

An Expanding System—Expansion has occurred. And the Change Office now carries on many pro-

DESIGN CHANGE CONTROL . . . continued

TELautograph network has been found economical and effective in getting design change data from the Data Center to "need to know" activities. Ed Jowett, Administrator Design Change Control and author transmit late action on a Douglas project to the Data Center.

grams simultaneously. A separate Design Change Board for each is formed under the direction of a Chairman assigned to the Design Change Control Office. Once drawings and specifications for a program are released, any change to be made is reviewed by the Board: This assures:

- Integration of the change among all affected operations.
- Concurrence with the recommended introduction point of the change and disposal of any existing materials.
- Completeness, clarity and understanding of the change.
- Conformity to the objectives of the program.

GE-MSVD believes that this approach to Design Change Control has solved most of its problems. To support this concept the Design Change Control Office has been made a focal point for change activity. It provides the necessary administrative back-up, guidance, organization, and consistency for the whole Change Control effort. The Chairman of the Board for each program must thoroughly familiarize himself with his program. He must organize his Design Change Board and conduct its activity within guidelines, rules and procedures of the Design Change Control function.

A System At Work—At GE-MSVD a change to a drawing or specification can be accomplished only by means of an Alteration Notice (AN). This form must define the change, identify the model and introduction point, and dispose of any existing material. An AN can change only one drawing or specification at a time.

Design Changes of a routine nature are submitted to the Design Change Control Office daily by 9 A. M. They must be submitted to the Change Control Office through a Board Representative from the initiating operation. It is expected that he will have reviewed the change to assure it meets standards and criteria of the Board. He must have sufficient knowledge of the change to be able to present it to the Design Change Board. Changes submitted by 9 A. M. each day are reproduced on "For Information Only" paper and, with an agenda, distributed throughout the Department by 11 A. M. daily. Personnel in the Department have approximately 24 hr in which to review the change.

The Design Change Board meets the following day to act on the change. It is either accepted, held for further investigation, or returned to the initiator on the basis that the change should not be made. Routine changes which are in order and meet the four objectives of the change review are processed in approximately 30 hr. Fig. 2 describes the flow.

Time Is Critical—Time is one of the major problems in most Design Change Systems. Success depends on the ability to handle a change quickly, yet provide close scrutiny of following: the four basic points:

- Integration
- Introduction and disposition of material
- Clarity and understanding
- Program Direction

To further reduce the time element, an "Emergency System" has been designed. The system puts the responsibility for the integration of the change with the Design Engineer. Yet, it assures compliance with the four points of integration. It requires a minimum approval of the Design Engineer, his Design Change Board Representative, Manufacturing, any other affected operations and the Chairman of the Design Change Board. It is the responsibility of the Design Change Board Representative and Design Change Board Chairman to assure the four basic points are met prior to approving the change on an Emergency Basis. Many changes are processed in less than one hour.

The Design Change Board for a particular program meets each day at a specified time. The Board Representative of an operation initiating

a change can request action by the Board on a limited number of changes (which have not previously been distributed for review) by bringing the changes directly to the board meeting. Such change must be accompanied by "Information Only Copies" for each board representative. By submitting a change in this manner, the risk is taken that some operations will request permission to hold the change until they have the opportunity for further evaluation. If, however, no problem is encountered, board approval of the change can be obtained immediately. This method again reduces the length of time required for change processing.

Serializing Changes—Since each AN can change only one drawing at a time, the AN number is the same as the drawing or specification

FIG. 2 ACTION FLOW ON "NORMAL" DESIGN CHANGES

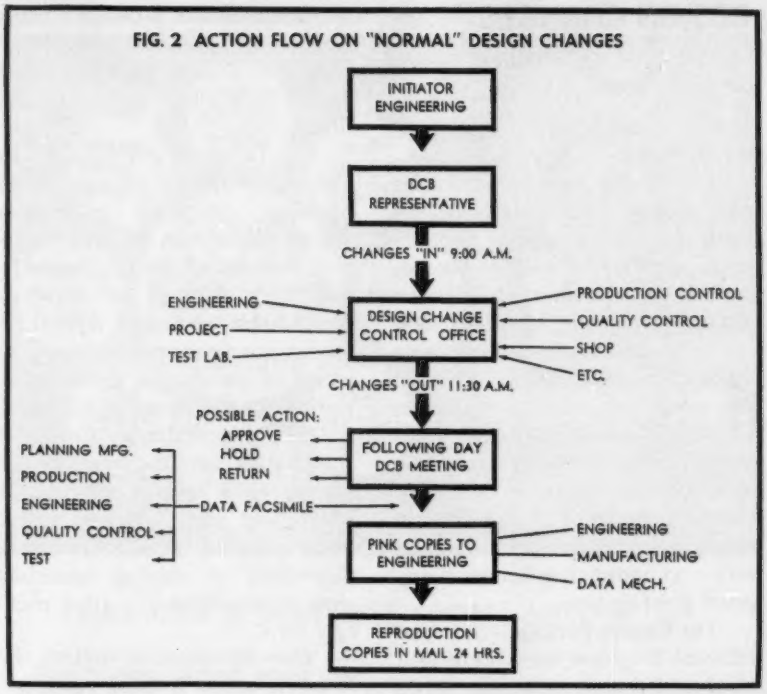


FIG. 3. MANUFACTURING INFORMATION SYSTEM

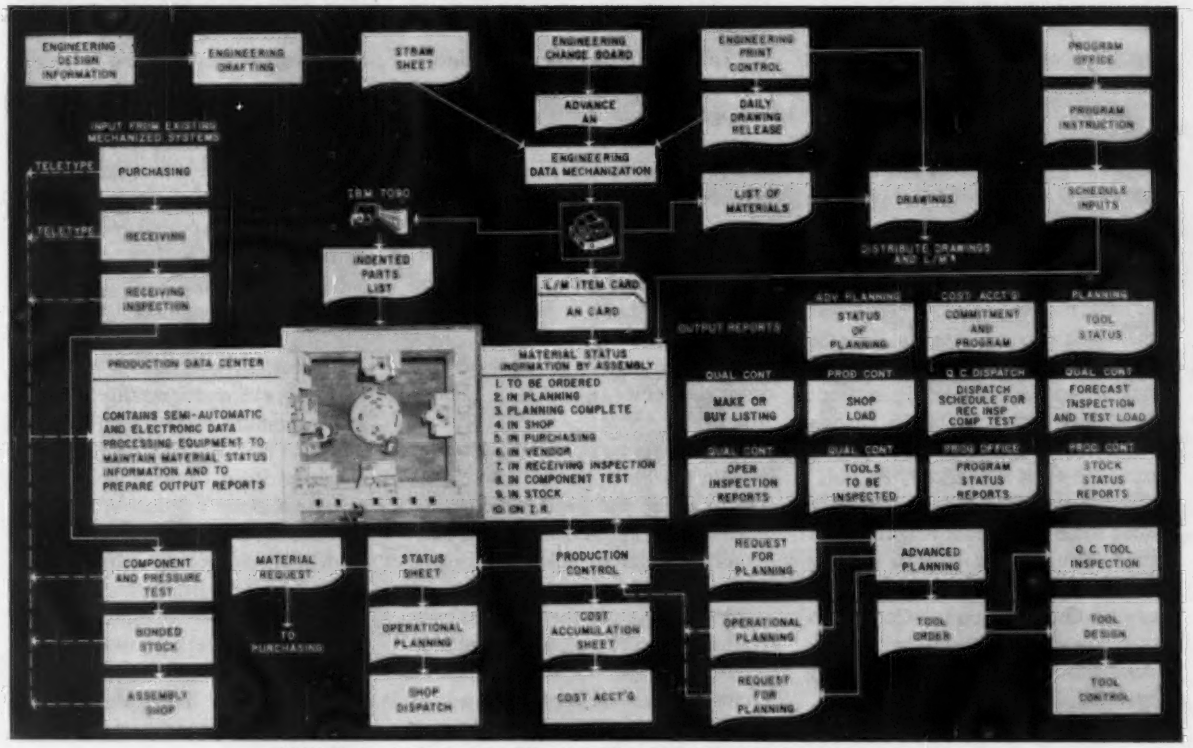


TABLE I "Data On File At Change Centers"

1. How many parts are due from the vendor of any part number?
2. How many parts have been received from the vendor?
3. Where are they located?
4. How many parts are in stock and to what AN's have they been built and tested?
5. How many parts are being made in-house?
6. In what stages of completion are they?
7. If completed where are they?
8. Does the part require qualification?
9. What is the qualification status?
10. On what models and program is the part used?
11. What is the next higher assembly number?
12. How many parts have been shipped in units? As spares?

DESIGN CHANGES

. . . continued

number it changes plus a dash number (825C895-1, 825C895-2).

GE-MSVD has adopted this type of system for several reasons. First, it ties any change to its drawing or specification number. Second, the number of changes in existence against any drawing or specification can be quickly determined by noting the dash number. Design Changes are never issued out of sequence. Third, this system allows any engineering group to release at any time as much information as is known about the change. This results in faster change action by permitting action on information known at any given point in time.

The Change Package—Since the GE-MSVD system does result in a number of change documents (AN'S and drawings), a document called an "Engineering Package Release" (EPR) is used to list all of the documents associated with any package of changes.

EPR's must be prepared by the engineering groups initiating the change when more than one change (AN) and/or drawing is involved. It must be submitted with the first AN when presented to the Design Change Board. As more engineering information is made known and other engineering groups release their portion of the change, additions are made to the EPR until all documents involved in the change are listed. Until all documents are listed, the EPR is marked "Partial." When all the change documents are issued the EPR is closed and marked "Final Issue." The EPR is a very useful document to the Manufacturing and Quality Control Groups to permit knowledge of all individual documents involved in the overall change.

An important portion of any change system is the support which is provided to the decision making group (Board). MSVD uses several mechanisms to assist the engineer and Design Change Board in making decisions. The first of these is the designation of a Design Change Board Administrator who is attached to Design Change Control Office. He has essentially two functions:

(1) To make preparations for each daily Design Change Board Meeting. (Distribute preliminary change information for review; prepare minutes of meeting, agendas; prepare a package of drawings, specifications and other support information necessary to support evaluation of the change; gather information on the status of hardware.

(2) To maintain a "Center of Information" on all changes (When submitted; if held or returned by whom and why; when approved; models affected; introduction points; disposition of existing materials; changes associated in a given package; etc.).

The Administrator follows up to assure action is taken on a particular change to make certain all requirements are satisfied prior to issue.

Information Dissemination—The second major area of support for the change control activity, is what is known as the "Manufacturing Information System." This system consists of a center in which vital information concerning any program is stored. Data are available to department personnel who have a need for this information in helping them with their daily problems. Information made available from the center is shown in Table I and Fig. 3.

An inexpensive communications system has been set up between the Data Center and need-to-know operations. It is a TELautograph electronic longhand telescriber. See Fig. 4.

We use picture transmitting equipment to permit quick distribution for copies of each approved change to critical locations such as Manufacturing, Planning, Test and Quality Control once the change is approved by the Board. Information on the latest approved change is available in critical locations within 15 min after approval. A formal later distribution is also made through normal channels.

Stop Then Go—A "Work Step Authorization" has been put into the system to authorize work stoppage when it becomes obvious change will be approved and will result in rework or scrapping of hardware. The work stop authorization, initiated from Engineering through the Design Change Control Office is signed by the Program Manager and authorizes work to be stopped so that further manufacture of incorrect hardware will be held to a minimum. This is transmitted to Production Control by Picture Facsimile Transmission.

Control of Drawings — MSVD uses the Group and Parts Drawing System. This system conforms to MIL-B-70327 and other Military Specification. Details concerning drawing preparation are well defined in a drafting manual which is maintained by a monitoring group attached to the Engineering Operation. This group also acts as a consulting group for drafting personnel in drawing procedures and practices. The drawing system is used to define prime hardware (flight) and its Support Equipment. It is for this drawing system that the Design Change method described is used.

Two other types of drawing systems are used. The first of these is a "Sketch Drawing." It is used by the individual engineer to describe hardware he wants to obtain for experimental or tinkering purposes. Requirement and formality are held to a minimum. The sketch drawing number is controlled and issued from the Print Control and Reproduction Group.

The second set of drawings used by MSVD approaches the drawing used for the formal system. This drawing system is intended for use to obtain engineering test hardware. Flight hardware is not built to this type of drawing. This system is regulated to the extent that formal drawings are required and if to be changed after issue a regulated change system is required.

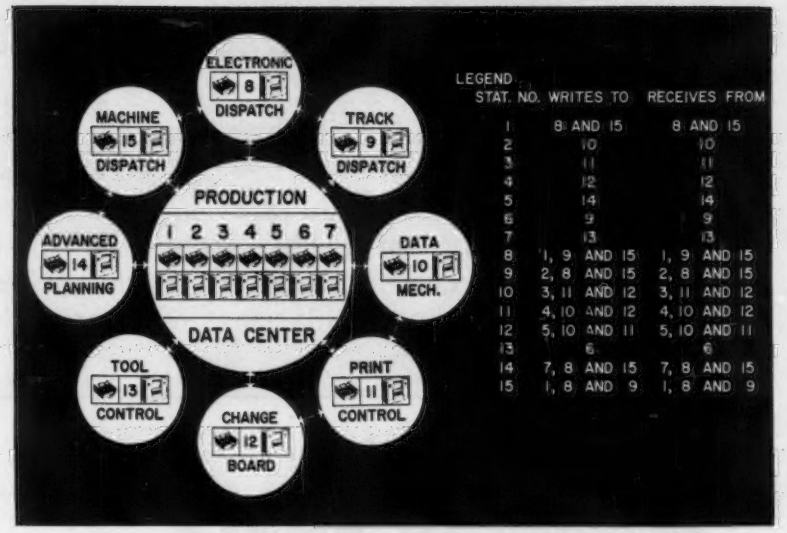
Since this intermediate drawing system is intended for use by Engineering for the development of en-

gineering components or end items test vehicles, the Manufacturing and Quality Control organizations act as an assist to engineering. To insure adequate definition of the engineering development hardware and to insure proper integration of design changes, it has been found necessary to use a reasonably formal change control system. This change control is also accomplished by means of a Design Change Board. The engineer must also describe his change on an Alteration Notice (AN). However, he is free to negotiate with the Manufacturing and Quality Control groups performing work for him. On this basis, and on his authority, action will be taken to proceed with the change. Immediately the change (AN) is sent to the Design Change Control Office where it is reviewed by the Design Change Board within 24 hr to assure the four points of change control are met. Facilities and services of the Design Change Control Office are used to assist in accomplishing design change integration for the intermediate type drawing system.

Since engineering development and test hardware built to the intermediate type drawing system is for engineering use, the Change Chairman is assigned from engineering. An experienced Chairman from the Design Change Control Office participates in the meetings as a consultant. A Print Control and Reproduction Group is established for releasing, reproducing and storing drawing and specification masters. Each time a drawing is revised a microfilm is made of the revision and stored in the Print Control and Reproduction Operation. A copy of each change notice (AN) is also reproduced on microfilm and filed. We use a Copy Flo Printer to get a copy of any previous revision drawing or specification in a matter of minutes. A record of the status and location of each drawing or specification master is maintained. With this technique, the status of any drawing master is known at all times. Numbers for changes are issued in succession from this Group. This task was initiated to eliminate change number duplication and to assure issuance of changes in sequence.

Any responsibile drafting or engineering section can remove a drawing or specification master from the storage crib. However, it can not be returned to the crib if it has been changed without an approved Alteration Notice (AN). The approved AN is the license to get the changed drawing or specification master into the reproduction and distribution area for reissue.

FIG. 4. ELECTRONIC LONGHAND NETWORK


ELECTRONIC 8 DISPATCH
MACHINE 15 DISPATCH
TRACK 9 DISPATCH
PRODUCTION
1 2 3 4 5 6 7
ADVANCED 14 PLANNING
DATA 10 MECH.
DATA CENTER
TOOL 13 CONTROL
PRINT 11 CONTROL
CHANGE 12 BOARD
LEGEND
STAT. NO. WRITES TO RECEIVES FROM
1 8 AND 15 8 AND 15
2 10 10
3 11 11
4 12 12
5 14 14
6 9 9
7 13 13
8 1, 9 AND 15 1, 9 AND 15
9 2, 8 AND 15 2, 8 AND 15
10 3, 11 AND 12 3, 11 AND 12
11 4, 10 AND 12 4, 10 AND 12
12 5, 10 AND 11 5, 10 AND 11
13 6 6
14 7, 8 AND 15 7, 8 AND 15
15 1, 8 AND 9 1, 8 AND 9

WHAT GOOD DESIGN-CHANGE CONTROL MUST INCLUDE

1. An orderly defined drawing and specification system which provides:
   a. Adequate storage for drawing and specification masters.
   b. Adequate distribution of up-to-date drawing and specifications at convenient locations (Blue Print Cribs).
   c. Means for quickly up-dating drawings and specifications, and distributing copies to replace those in use.
   d. A system to assure drawing and specification masters are not changed and released without proper authorization.
   e. A system to assure continual knowledge of the location of drawing masters once removed from the storage area.
   f. An easy access file to previous drawing revisions.
2. An orderly system for giving initial release of design.
3. An orderly method for accomplishing changes once the drawing or specification is released to:
   a. Integrate the changes among all affected operations.
   b. Establish an introduction point and dispose of existing materials.
   c. Assure changes as defined are correct, clear, complete and understood.
   d. Assure proposed change is in accordance with overall program direction.
4. Speed in effecting change action.
5. A procedure for non-engineering groups to request changes might be to their special "convenience."
6. A central location for knowledge of the status of any change.
7. A central organization to provide department change control guidance and organization.
8. A central location where the status of existing hardware is known. Specifically:
   a. Quantities of hardware in existence.
   b. Stage completion of hardware and its location.
   c. Where hardware is used.
9. A procedure for releasing the change and a follow-up to assure all portions of the change are provided.
10. A personnel education plan in "change control" procedure.

Print cribs are located at critical points throughout the department. Copies of drawings and specifications are available in these locations. A copy of the change (AN) is filed in each crib within 24 hr and is attached to its drawing in the cribs within 48 hr. ✦

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What happens when missile manufacturing techniques start to lag behind the state-of-the-art? Costs stay unnecessarily high! To make sure this doesn't happen in Pershing propulsion, Thiokol has set up a technical staff to constantly review materials and processes and submit cost cutting proposals. Early studies show that substantial, even spectacular cost reductions are now possible.

SLASHING COSTS On Pershing Propulsion

by **John P. Kushnerick,** Managing Editor

► Spectacular cost reductions are possible in Pershing's propulsion. Converting to a filament-wound reinforced-plastic motor case would in itself reduce the direct cost of a set of motor cases more than 50 per cent. This would amount to a saving of $20,000 per set. Thiokol has formally proposed this switch to Martin and Army in a detailed value analysis document.

The Thiokol Value Engineering proposal includes 39 ways that new materials and processes could chop Pershing costs. Not all are so spectacular.

Another case fabrication technique, called the "hot-cup cold-draw method" could effect similar savings, should the switch to plastic be considered too drastic. This manufacturing process would eliminate all welds from the case.

Thiokol has asked for $2.92 million to further study and effect some of these value concepts. Savings could total hundreds of millions in a long-run contract. But, it appears that Army is willing to fund only about $600,000 to $700,000 of the work.

State - of - the - Art Advances—Present design of the Pershing propulsion system is based on materials and processes known to be satisfactory when the project got underway. There have since been many advances in the state-of-the-art. Only those changes which do not affect the compatibility of the propulsion system with the rest of the missile are included in the Thiokol proposal.

Some of the proposed concepts, however, involve changes that are extensive enough to warrant static firing tests. Five sets of motor inert components, at a total cost of $323,120, would be needed to test the proposals listed in Table I. (A set consists of one Pershing XB-1 and one XB-2 motor, Propellent, case liner, and bonding agent costs are not included.) Delivery schedule of the five motor sets would be as follows, if the proposal is funded:

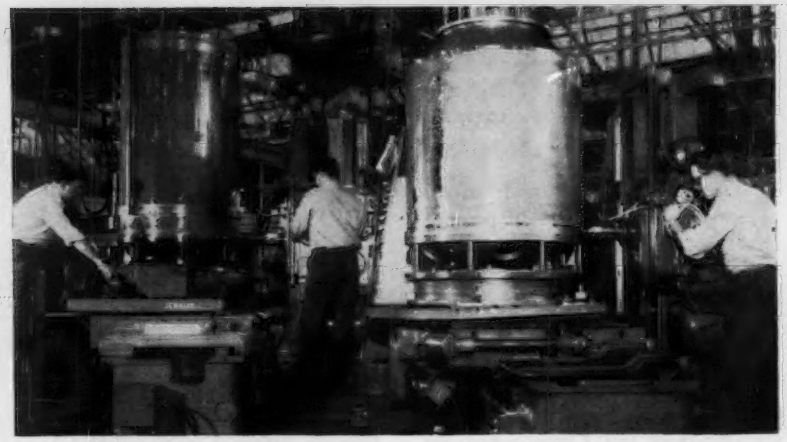
- One set of components January 15, 1961.
- Two sets of components February 1, 1962.
- Two sets of components February 15, 1962.

The changes suggested in Table II require more extensive testing. Neither the number of test pieces nor the exact test cost has been detailed.

Filament Wound Case—Pershing motors are made from vacuum —Consutrode H-11 steel at present. The head and aft domes are machined from 4500-lb forgings. This is expensive. A lot of material ends up as machine chips.

The case cylindrical section is made by spin-forming blanks that are machined from rolled-ring forgings. The walls are about 0.080-in. thick when completed and have a slight taper. To complete the case, the domes are welded to the cylindrical section. Quality of the welds is critical, they are therefore carefully inspected. The weldments must be heat treated, which includes preheat, normalizing austenizing, quenching, tempering, and straightening. Before the case is completed it must be assembly machined, drilled and tapped, all to close tolerances. More than 500 different operations are performed on first and second stage Pershing cases at Pratt & Whitney's East Hartford plant. All are time consuming and expensive operations.

Thiokol has requested funds to transition from steel to reinforced plastic cases. Head and aft dome



First and second stage Pershing cases are machined simultaneously after the forward and aft domes are welded in place. Not all of the 500 operations performed at Pratt & Whitney have this inert economy. Machining the second stage forward dome is very expensive. Thiokol proposes to give P&W a $100,800 subcontract to perfect a machining method called "skip-turning."

insulation could be made an integral part of the plastic case. This would eliminate the separate installation costs.

The decreased weight of the plastic case would result in a range increase with no change in propellent weight. Or, should present weight prove to be important, more propellent could be added to further increase range.

Adopting the filament winding technique would reduce direct costs of the Pershing by decreased inspection costs, and reduced shipping weights would effect further savings. At an estimated saving of $20,000 per motor set, the cross over point would be reached after the manufacture of 20 sets of filament wound motors.

"No-Weld" Case—Switching to plastic is not the only way huge savings can be made in the Pershing motor case. Thiokol estimates that a fabrication method called the "hot-cup, cold-draw" would also result in savings of $20,000 per motor set. But, since change-over costs would be higher with this method, the break-even point would not be reached until 43 sets of motors were produced.

The chief advantages of the hot-cup, cold draw process are:

(1) Would use only 2000 lb of raw steel for the manufacture of both stages. At present each head and aft dome are machined from 4500 lb forgings.

(2) Reliability of the case would be increased since the "cold draw" of the cylindrical section would completely eliminate weldments.

(3) The process lends itself to the use of vacuum degassed steel, which is one-half the cost of vacuum-Consutrode material. The only reason for use of this high priced steel at present is the weldability factor. Use of vacuum degassed H-11 or D6C would in itself cut $1400 from the cost of each motor.

(4) Better weight control would be obtained, since the process allows very close control over inside and outside wall-tolerances.

Less Spectacular Savings—There are many other value engineering changes that could cut Pershing costs. They are less spectacular, but some can be effected more rapidly.

NOZZLE-TO-CASE-JOINT: Blind nuts (72 on 1st stage and 60 on 2nd stage), individually machined and assembled to the case, are now used in the nozzle-to-case joint. Each nut uses an O-ring to seal in internal pressure and is swaged in place on the case and prevented from rotating loose by a dowel pin. The chance of seal deterioration on each test firing makes reuse of the motor case questionable.

Thiokol proposes to develop a method for bottom tapping the attach bolts and thus eliminate the machining and assembly of each nut. Nut clearance counter sinks on the nozzle flange face could be eliminated.

The change would increase case reliability and cut costs by $575 on each motor set. Cross-over point is calculated at 73 motor sets.

ELIMINATE DELAY: A five hour delay is called for in current processing specifications before the final propellent mix can be poured into the case. The delay is to assure that previously loaded propellent has fully contracted before the curing cycle is started. Since the pot life of the PBAA (Polybutadiene acrylic acid) propellent mix is less than delay time allowed for contraction, three separate mixes are needed in loading the XB-1 motors.

Thiokol has discovered, through preliminary measurements, that there is no detectable contraction of the propellent before or during the curing process. Should further extensive study bear this out, the five hour delay could be eliminated at saving of $1113 per XB-1 motor. The cross-over point for this saving would be 5 motor sets.

PROPELLENT ACCEPTANCE: Present practice is to manufacture five batch check TX3-1 motors per mix and to fire four of these at three different K_n's and temperatures. The pressure and burning rate in a large Pershing motor is then estimated at the actual K_n.

Thiokol's Utah Div. finds that strand burning rate data can be substituted for batch check motors on the TU-137 motor. It has proposed to study whether this is also true

SLASHING COSTS . . .

continued

on the Pershing motors.

Use of uncured strands in the acceptance tests would permit checking the ballistics of each mix before pouring it into the full-scale motor. Out-of-tolerance mixes could be adjusted and rejects of motors would be eliminated.

Savings of $2050 per motor set would be a direct result of the strand burner test. Cross over point would occur at 4 motor sets.

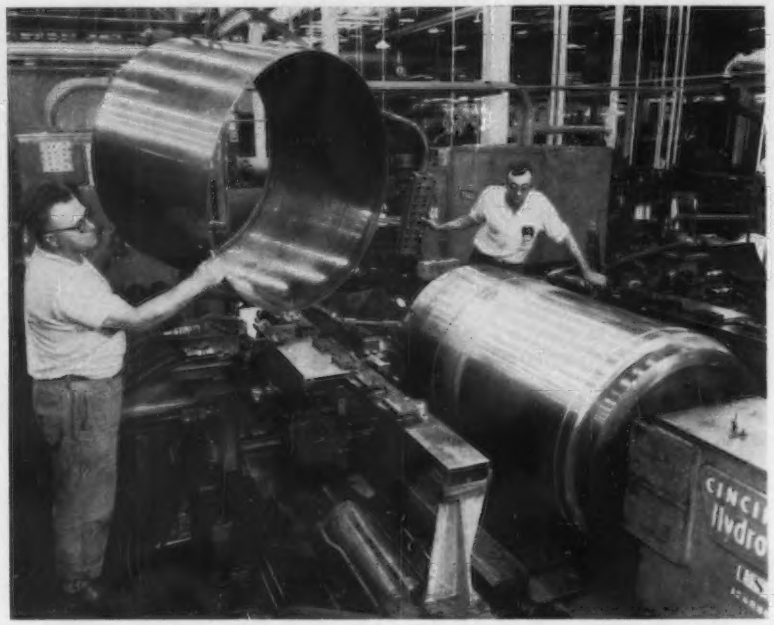
ELIMINATE COOL DOWN: A required step in the standard procedure for processing motors containing H-series propellents is a controlled cool-down at the rate of 8 deg F every 8 hr. This control means the motor must stay in the curing pit for 40 hrs after the cure has been completed. Turn-over rate for each pit is reduced, man-hour charges are increased.

It is proposed that the effects of shutting off the heat at the end of cure and allowing the propellent to cool naturally to the desired temperature for mandrel removal and finishing operations be studied in test motors.

Adopting this concept would give a direct saving of $120 per motor set and would increase the cure-pit turnover rate. Cross-over point for the saving would be reached after manufacture of 12 motor sets.

RECLAIMING CASES: A lot of time and effort has gone into recovering cases from rejected motors. Removing the materials from the case is the problem. Methods investigated include solvent soak, mechanical drilling, underwater burnout, and high-pressure water jets.

Solvent soak has proven impractical because it takes too long. Mechanical drilling is considered unsafe. Underwater burnout has been effective for a limited class of motor. Water-jet clean out has demonstrated the broadest range of capability.



Cylindrical section of both first and second stage Pershing motors is spin-formed to 0.80-in. thickness by Pratt & Whitney. Forward and aft dome closures are then welded in place. Thiokol proposes to give Lyon Machine Tool Co. an $820,000 value engineering contract to perfect a "hot-cup," "cold-draw" technique that would eliminate all weldments.

A proposal has been submitted to optimize a high-pressure water-jet system for Pershing motors. This includes:

- Fabricating or modifying tooling.
- Determining proper hydraulic pressure.
- Determining proper impingement angle.
- Determining proper nozzle design.
- Determining proper rotation speed for nozzle.

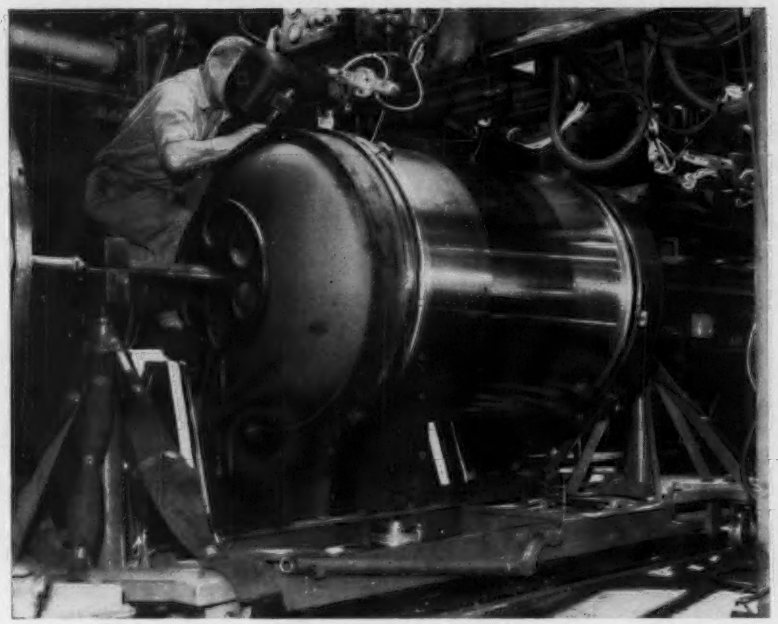
All known types of detective propellant can be removed by this method. But the thin-walled, high strength steel cases, the molded-plastic insulation, and the plastic slivers used in Pershing motors offer a set of conditions that need further study.

A direct monetary value is very difficult to set in savings to be realized by reclaiming motor cases. But, it has been estimated at $1800 per motor set. The cross-over point could be about 17 motor sets.

PRECISION DOME FORGINGS: There is a web thickness of almost one inch on the forgings from which case domes are manufactured.

By designing and building new forging dies for the forward and aft motor case domes of both stages a saving of $1500 per motor set could be realized. The dies would produce forgings with a web thickness of ½ in. The cross-over point for realization of the savings would be 64 motor sets.

Further savings in forging dies could be realized by designing a new die for the first stage dome which would not include provisions for reverser ports. At present, the same forging is used to manufacture the forward head dome of both stages. Because a thrust reverser port must be machined from the second stage dome, excess material is provided on the forging. When using this forging to make a first stage dome, the material must be machined off. This increases scrappage and manpower costs. By using an optimized forging die for the first stage for-



To obtain welds that are practically free of porosity and inclusions, Pershing motors are fabricated from a high-purity raw material (vacuum melted, Consutrode steel). Preliminary tests indicate that vacuum degassed H-11 and D6C steels give equal welds if handled properly. Thiokol proposes to save $1400 per motor set by making the switch in raw materials. Cross-over point for the savings is 58 motor sets.

ward dome, $275 would be saved per motor set. The cross-over point would be reached after production of 76 motor sets.

SKIP TURNING: The forward dome of the second stage Pershing motor case contains three reverser ports and an igniter boss. The machining technique now in use is to contour turn the inside surface, and to "keller" and hand-blend the outside surface contours. Machining the outside surface therefore is essentially the same as the time-consuming method used to machine dies.

Thiokol's value engineering studies show that it would be feasible to machine the ouside contour by "contour skip-turning," i.e., contour-turning around the three reverser ports and bench blending. Funds are needed to develop tooling and further study the technique.

It is estimated that a $225 saving could be realized on each motor set using this new technique.

. . . continued on next page

Table I—COST SAVING STUDIES FOR PERSHING

Recommended For Early Funding Total Cost $930,785

Purpose of Study	Cost of Implementation	Time (wks)*	Saving Per Set‡
1. Nozzle-to-Case Joint Modification for Pershing Motors	$89,821	33	$575
2. Pyrogen-to-Case Joint Modification for Pershing Motors	$76,231	32	$400
3. Precision Forgings for Head and Aft Dome of Motor Cases	$206,541	26	$1500
4. Skip-Turning of Second Stage Motor Case Forward Dome	$215,663	40	$225
5. New Forging Die for First Stage Forward Dome	$44,957	12	$275
6. Air-Melted Steel for Forward and Aft Case Skirt Extensions	$78,930	21	$330
7. Low Cost Material for Nozzle Entrance Cone Liner	$12,938	8	$400
8. Improved Nozzle Entrance Cone Fabrication Method	$59,105	13	$1000
9. Improved Nozzle Exit Cone Liner	$19,826	22	$500
10. Evacuation of Propellant Casting Lines	$4095	15	$500
11. Reclamation of Pershing Motor Cases from Reject Motors by High-Pressure Jet Cleanout	$63,107	14	$1800
12. Study to Eliminate the Five-Hour Delay Period in Processing Pershing Motors	$3816	34	$1113
13. Elimination of Controlled Cooldown of Motors	$3165	15	$120
14. Strand Burner Acceptance of Propellant Batches	$15,823	26	$2050
15. Design and Evaluation of Pyrogen Adapter Inspection Fixture	$9401	14	$49
16. Design and Evaluation of Reverser Tube Inspection Fixture	$6702	8	$32
17. Design and Evaluation of Inspection Fixtures for Pershing Motor Inert Slivers	$12,845	7	$84

(*) *Time from authorization of study to start of production.*

(‡) *Motor set consists of all components necessary to produce one Pershing XB-1 and one XB-2 motor.*

Table II—COST SAVING STUDIES FOR PERSHING

Require Detailed Study Total Cost $1,990,782

Purpose of Study	Cost of Implementation	Time (wks)*	Saving Per Set‡
1. Flash Butt Welded Ring Blanks for Flow-turned Cylinders	$65,895	27	$1525
2. Hot Cup, Cold Draw Case Fabrication Method	$955,177	56	$20,000
3. Use of Vacuum-Degassed Steel in Cases	$88,391	39	$1400
4. Filament Wound Motor Cases	$441,755	39	$20,000
5. Improved Manufacturing Process for TX-175 Reverser Tube Insulation	$6968	13	$48
6. Light-Weight Low-Cost Plastic Nozzles	$78,636	30	$4100
7. Improved Technique for Molding XB-2 Head-End Insulation (1-Piece, Flexible)	$39,816	28	$510
8. Improved Molding Techniques for Pershing XB-1 Head-End Insulation	$9158	17	$50
9. Hermetic Sealing of Initiators	$11,148	21	$87
10. Corrosion Resistant Coating for Exploding Bridgewire Initiator Contacts	$4977	21	$24
11. Hazards Classification Reduction for Pershing Pyrogen Propellant	$23,491	21	$225
12. Propellant Mixer Capacity Studies	$24,686	13	$500
13. Study to Reduce the Number of Voids	$26,876	30	$3120
14. Single Coat Liner for Pershing Motors	$10,352	13	$215
15. Selection of a Better Solvent for Removal of PBAA Compositions from Cases	$10,949	16	$94
16. Dimensional Tolerance Relaxation Study	$44,195	52	—
17. Study of Porosity in H-11 Steel Case Welds	$33,246	17	$7000
18. Review Material Specifications and Acceptance Test Procedures	$22,098	52	—
19. Study to Establish More Realistic Inspection Standards for Pershing Pyrogen Motors	$8162	26	$100
20. Chemical Analysis of Propellant	$10,750	10	$65
21. Revision of Drawings to Facilitate Inspection	$7764	15	$238
22. Development of Propellant Profilometer Inspection Techniques	$66,492	28	$500

MANPOWER COSTS

For Value Engineering Studies Suggested In Table I

OPERATIONS	Exempt Hours	Rate	Non-Exempt Hours	Rate	Amount
Operations Planning Department	84	4.27	167	2.45	$767.83
Propellant and Process Development Department	609	3.95	1,216	2.45	5,384.75
Operations Services Department	426	4.41	850	2.70	4,173.66
Pilot Lines Department	243	3.93	483	2.35	2,090.04
Quality Department	370	4.34	741	2.75	3,643.55
Engineering Department	3,152	4.41	6,303	2.66	30,666.30
PROJECT MANAGEMENT					
Project Management	3,463	4.58	6,926	2.20	31,097.74
Total Direct Labor					$77,824.00

VALUE ENGINEERING SUBCONTRACTS

Proposals Suggested In Table I

Subcontractor/Purpose	$ Contract Value
Pratt & Whitney Aircraft for Nozzle Attachment Joint Modification	29,325
Pratt & Whitney Aircraft for Pyrogen Attachment Joint Modification	29,050
Curtis Wright Corporation for Precision Dome Forgings	96,550
Pratt & Whitney Aircraft for Skip-Turning of Second Stage Forward Dome	100,800
Pratt & Whitney Aircraft for Precision Forging Die	21,000
Curtis Wright Corporation for Air-Melted Steel Skirt Extensions	33,500

Proposals Suggested In Table II

Pratt & Whitney Aircraft for Flow-Turning Blanks	53,350
Lyon Machine Tool Company for Hot Cup, Cold Draw Case Fabrication Process	820,000
Curtis Wright Corporation for Vacuum Degassed Steel Study	60,000
Douglas Aircraft Company for Filament Wound Motor Case Program	225,000
Dumont Manufacturing Company for Light Weight Low Cost Nozzle Program	45,500
Interdivisional Work Order to Hunter Bristol Division-Thiokol for Forward Dome Tooling	27,000

SLASHING COSTS . . . continued

PLASTIC NOZZLES: Both the Pershing XB-1 and XB-2 rocket motors use plastic nozzles. The design incorporates molded-ablative, erosion-resistant liners in the convergent and divergent sections, a graphite throat insert and steel attachment rings. The weight penalty of the steel attachment is obviously great. Thiokol believes the state-of-the-art in materials is now advanced far enough to eliminate the steel and use an all-plastic rocket nozzle. A saving of over $4000 per motor set could be realized from an all-plastic nozzle. Cross-over point would be 17 motor sets.

IMPROVED NOZZLE ENTRANCE: Short of going to an all-plastic nozzle, improving the fabrication method on the nozzle entrance cone could result in savings of $1000 per set of nozzles.

Longitudinal structural materials in the convergent section of the nozzle are applied in two separate laminating steps. The first laminate is laid-up adjacent to the entrance cone-liner. The laminate is hydroclaved and machined to finish contour. Circumferential rovings are then applied over this first laminate, cured, and finish machined. The second longitudinal laminate is laid up over the circumferential rovings. The unit is cured and machined to final dimension.

Circumferential rovings could be applied directly to convergent section liner. The longitudinal material could be applied in a single operation over the circumferential rovings. One laminating set-up, one hydroclave operation, and one machining operation would be eliminated. About $1000 would be saved on each set of nozzles. And the cross-over point for the change would occur after producing 28 motor sets.

IMPROVED NOZZLE EXIT: Exit cone liners for tactical missiles are molded from FM-5010 chopped graphite-fabric compound. The molding technique highly orients the small squares of graphite fabric compound in a plane parallel to the surfaces of the exit cone. This orientation is believed to be the primary factor in exit cone spalling.

It is proposed to investigate fully a switch to FM-5014 chopped graphite-fabric molding-compound. This material has a much lesser tendency to fiber orientation. It costs $2/lb less than the present compound. Char and erosion characteristics look equal to or better than FM-5010 in small-scale test motors.

The use of FM-5014 should decrease the cost of a set of nozzles by $500. It would also decrease the weight of each nozzle by at least 10 lb. Savings cross-over should occur after 19 motor sets are manufactured.

NOZZLE ENTRANCE LINER: The entrance liner on Pershings plastic rocket nozzle is a composite, high-pressure molding of an erosion resistant material (FM-5014) and a heat resistant material (Durez 21066). Manufacture entails fabricating two performs, one of each material, and then molding them together.

Material and process value analysts believe that FM-5014 and Durez 21066 can be replaced with a high-silica fiber-phenolic material which will serve as both a heat and erosion barrier. The preform operations and the handling of the two materials would be eliminated. A total cost reduction of $400 per set of motors would result. Cross-over point to realize the savings would occur after production of 15 motor sets.

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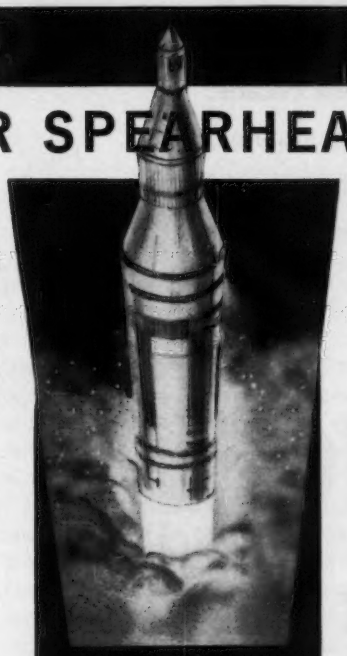
FORGING OUR SPEARHEADS IN SPACE



1 Titanium motor case parts totalling 2010 lbs.
2 ICBM heat sink cone; Copper, 1876 lbs.
3 Ported motor closure; 74 lbs., Aluminum.
4 Magnesium turbopump ring gear; 35 lbs.
5 Sustainer ring; 208 lbs., alloy steel.
6 Aluminum airframe ring splice; 53 lbs.
7 Missile blast cone; 237 lbs., carbon steel.
8 Stainless steel injector plate; 155 lbs.
9 Payload container; 10 lbs., Beryllium.
10 Super-strength steel head; 725 lbs.
11 Missile fin spar; 65 lbs., Aluminum.
12 Thrust cone; 613 lbs., alloy steel.
13 Power system part; 1300 lbs., Columbium.
14 Titanium igniter nozzle; 122 lbs.
15 Pressure bottle half; Titanium, 173 lbs.
16 Astroloy turbopump wheel; 170 lbs.
17 Heat shield backup; 134 lbs., Magnesium.
18 Airframe wind arm; 129 lbs., Aluminum.
19 Super-strength steel, 3100 lb. head.
20 Alloy-steel missile bulkhead; 130 lbs.
21 Tungsten nozzle throat insert; 115 lbs.
22 Aluminum sustainer thrust cone; 110 lbs.
23 Aft closure; 1600 lbs., super-strength steel.
24 Airframe rib spar; 95 lbs., Titanium.
25 Motor-case Titanium closure; 590 lbs.
26 Missile bulkhead; Aluminum, 89 lbs.
27 Beryllium guidance carrier ring; 23 lbs.
28 Booster turbowheel; Rene 41, 948 lbs.
29 Rocket spur gear; 18 lbs., Magnesium.
30 Magnesium satellite canister; 229 lbs.
31 IRBM Jetevator ring; 45 lbs., Molybdenum.
32 Missile motor Copper blast cone; 88 lbs.
33 IRBM spacer ring; 78 lbs., Tungsten.
34 Aluminum longeron for ICBM; 36 lbs.
35 Launching shoe; 26 lbs., alloy steel.
36 Columbium power system part; 1100 lbs.
37 Tungsten thrust-chamber throat; 32 lbs.
38 Glide vehicle component; Rene 41, 3 lbs.
39 Beryllium guidance main shaft; 9 lbs.
40 Launch vehicle domes; capability to 160"

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GR7

There is little doubt that aerospace efforts shall continue to expand in the next decade. The attendant growth in aerospace systems, however, may not necessarily imply a promising market for electronic checkout equipment.

WARNING:

Electronic AGE Market due for decline

by **Solomon S. Fineblum,** Consultant Research Engineer

► The present market for electronic checkout equipment is impressive. It has been estimated that up to 80 per cent of all Aerospace Ground Equipment (AGE) is in the nature of checkout equipment.

Basic function of this checkout equipment is to verify, prior to a mission, the operating condition of the systems, subsystems, and circuits. Checkout procedure, in general, is as follows: A fixed signal is fed into a component or circuit to be tested, and the output is compared with a reference output. If the difference between signals is within tolerance, a "Go" signal is generated. This "Go" signal can be read out individually by an operator or it can be fed into a sequential or automatic checkout device which switches to the next step. If the output, however, is beyond the permissible tolerance, then a "No-Go" signal results. In the case of an individual operator, this "No-Go" signal initiates a more detailed checkout or a repair routine. In automatic devices, the "No-Go" signal generates a sub-routine to more-exactly identify the location and the nature of the deficiency.

Hence, the checkout equipment tends to comprise circuit combinations of telemetering and computing devices. Automatic checkout equipment is mostly in the nature of a computer. It automatically does the following: processes the inputs versus the outputs; comes to a conclusion as to the significance of the measured transform function; and selects a sub-sequence for the remainder of the test operation.

Nature of Equipment—The present electronic checkout product line is characteristically very similar to in-plant checkout and inspection equipment with one basic difference: for field mobility, the equipment is mounted in a van or in a cart. Connected with "adapter" units, the system is used to check a particular vehicle. In fact, it has been noted that much of the checkout equipment although specifically developed for a particular vehicle has later been shown to be useful for in-plant checkout and inspection processes.

Now let's review the trends which are influencing the design philosophy for checkout equipment.

Mobility and Speed—Modern-warfare concepts are based on mo-

Most market analyses are based on simple extrapolations of current dollar-volumes. As a more realistic forecasting tool, the author suggests the superimposing of a technological analysis and change on this purely dollar-market analysis. Using this technique, he predicts a series of downtrends for electronic checkout equipment by 1970:

- **A decrease of about 50 per cent, from the extrapolated market, due**

bility and quick-reaction capability. If the amount of equipment that must accompany a vehicle is reduced, mobility would be increased. Likewise, if checkout procedures could be compressed or eliminated altogether, quick-reaction capability would be enhanced. So, we can predict with reasonable certainty that in the development of future aerospace systems great efforts will be made toward checkout simplification.

Automatic Checkout — Automatic checkout to save time and skilled labor has long been a popular concept. It was once feared that all automatic checkout systems would be special purpose. There are still arguments on the relative costs and complexity of multi-purpose adapter systems. Nevertheless, about half of all automatic checkout systems reported in recent years and most of the later ones are claimed to have multi-missile capability. This contributes to, rather than detracts from, standardization.

Standardized Checkout — The need for standardization as a cost-reduction device has also been long recognized by users of checkout equipment, and has been more and more incorporated into specs and requirements for weapons systems. It can be accepted as a generalization that most major vehicle systems have much of the checkout equipment in a partially-standardized form. Future systems will not require entirely new specialized checkout equipments. As a result of standardization we will be able to use much of the equipment that exists now.

Standardization is both vertical and horizontal. That is, the same piece of equipment can be used at various stages in the production-to-use cycle, and the same piece of equipment tends to be applicable to more and more different vehicles.

It has been estimated that as much as 85 per cent of all checkout functions are common to most vehicles. Hence, ultimately it can be anticipated that about this percentage of all checkout equipment will be standard. This suggests for the future that standardization will have a great effect in reducing electronic AGE costs as well as sales. It is important to note that progress in standardization and progress in automatic checkout often accompany each other.

Solid State Electronics — The main accomplishment of solid state electronics, from an operational point of view, is the incorporation of electronic circuit functions into tiny, physically-stable devices. Vacuum electronic devices, on the other hand, are assemblies of relatively fragile thin wires and plates suspended in a vacuum of inert atmosphere. Typical of one of the accomplishments in this area is a process well-known as potting, where a number of solid state devices are assembled and this entire assembly is immersed in a plastic. This forms a three-dimensional rigid body that protects all the individual components from transient loads and other damaging environmental influences. Consequences of solid state accomplishments are briefly: miniaturization, modularization, and enhanced reliability. The operational and economic consequences of these will be examined later.

Modularization — This consists of using expendable or at least removable modules, with a minimum of test points. An operational consequence of electronic modularization is a decreased time-to-ready. Now entire systems and sub-systems can be efficiently encapsulated in one modular unit. Testing is based simply on the transform function across this particular unit and in case of a deficiency, the entire unit is removed and replaced. The resulting economic implications need no elaboration.

Subminiaturization — The Subminiaturization of aircraft and missile guidance and control systems is the most dramatic result of advances in applied solid state electronics. One startling aspect of this development is the unexpected speed with which subminiaturized systems are going into production. Inherent in this advance is the simultaneous improvement of system reliability.

New Logics Are Flyable—The new logics that were developed for automatic checkout, when combined with advances in subminiaturization, make it possible to incorporate the

to standardization.

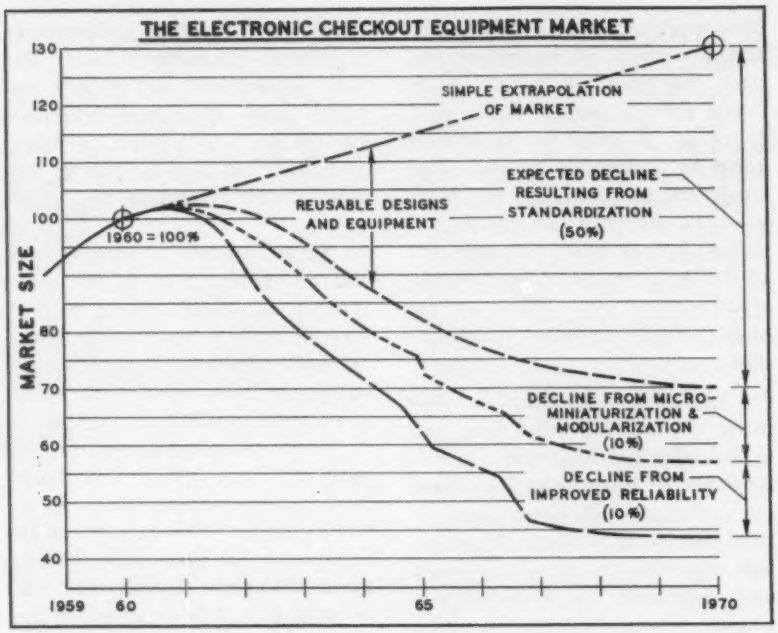
- **A decline of about ten per cent resulting from simultaneous microminiaturization and modularization.**
- **A loss of at least ten per cent from increased reliability.**

concepts of automatic checkout into the vehicle itself. In general, we have a combination of subminiaturization and the new self-corrective logics. Subminiaturization tends to make the self-correcting circuits practical, because now, redundancy and logic sub-circuits add only a tiny increment to the total system volume and weight. So, now, it is economical to incorporate automatic checkout and self-correcting, highly redundant circuits into the vehicle itself.

Improved Reliability—As reliability continues to improve, less checkout equipment will be required. As stated earlier, solid state and microminiature components are inherently more stable and reliable. New logics and circuit designs have produced systems that remain reliable in spite of component failures. These self-checking and self-repairing circuits have already been used in equipment and make possible entire guidance and control systems that can be built to take care of themselves. Fluid control systems of high reliability can also be produced to replace some electronic systems.

Having reviewed the effects of recent trends on electronic AGE design, let us now project their influence on future markets.

Standardization Effects — Let's assume that standardization is the fire trend to change the present market. Even present systems have sufficient standardization, to an extent that their replacements will be quantitatively fewer. For instance, it has been noted that 50 per cent of the checkout equipment for the Sergeant is general-purpose and applicable to its successors. To be conservative, let's assume that the decreased caused by standardization is not felt until sometime in 1962. If we consider all the electronic checkout functions which could be made interchangeable and standardized, the estimated decrease is close to approximately 80 to 85 per cent. Theoretically, we could come to a point where 85 per cent of all the units required for any particular vehicle are standard and have already been produced for an earlier vehicle, hence they do not have to be individually procured for the new vehicle. Again, being conservative, we will use the number of 50 per cent rather than the 85 per cent. So just to predict the effect of standardization, we will take the present upward curve, allow it to continue for a few years, then show a decrease to about 50 per cent of the projected electronic checkout market in ten years.



Modularization—There are already micromodules which require less checkout than their predecessors. It is predicted that by 1963 subminiaturization will be the rule rather than the exception for missile electronics. Therefore we will predict that about that time the market will have decreased further. Authorities predict that by 1963 and 1964 thin-film circuits will be in full production. This also suggests a decrease.

Next step in miniaturization is a process which results in integrated circuits. These should be in production in about 1963 or 1964. A decrease is again likely during this period because microminiaturization will prohibit a detailed checkout. The decrease caused by microminiaturization and modularization,

THE MORAL OF THE HAND CRANK

The prediction of a decrease in electronic AGE in the light of the present upward slope of the curve may be easier to understand by reviewing a similar change that occurred in a different industry. Automobile starter cranks increased from about 4000 in 1900 to more than 3 million in 1927. A quantitative analysis of the automobile hand crank market in 1927 would have shown a steadily increasing rate in the dollar value and unit sales.

However, between 1912 and 1914, many American automobiles had been equipped with self starters. Since then, the hand crank was supplied as an emergency-means of starting the car. In some cases, including the famous 1923 Model T, the hand crank was permanently attached to the front of the engine. In other cars, it was carried inside, just "in case." This entire period was one in which the engine and automobile ignition system, in general, and the self starter, in particular, grew appreciably in reliability and acceptance. Thus, the hand crank became obsolescent, and after 1930, was no longer issued as standard equipment on many cars. Soon thereafter, use of the hand crank was completely abandoned.

In this instance, a purely quantitative extrapolation of the sales curve could have led to an incorrect conclusion. Yet, a technical study into the purpose and function, which the automobile hand crank fulfilled, would have directly suggested its limitations.

Author Fineblum

. . . extrapolation is not enough . . .

is simultaneous with the decrease caused by standardization. As a result, we can predict that the market will be down to about 40 per cent of what it would have otherwise been with no technological change in ten years.

Increased Reliability—A third trend that will influence the future electronic AGE market is that of increased reliability. Reliability is increasing by orders of magnitude, both as a result of the improvement in the components and the methods of packaging and assembling, also through the incorporation of relatively-stable, and self-correcting systems. With the increasing use of stable circuit logics and inherent redundancy, the checkout process becomes less necessary. The effect of this reduction is difficult to quantify. However, it can be conservatively estimated that from 1962 until 1970, ten per cent of the total market will be lost as a result of this increase in reliability.

Re-Interpreting $ Curves—The above technological analysis has shown the relationship between the function of electronic checkout and the new technology. It has also shown how the new technology will change the mode of fulfilling the needs and functions of electronic checkout. The analysis has established a physical basis on which to re-interpret the dollar-market curves. Thus, on the basis of changes caused by technology, it seems that any expansion in the electronic checkout will be short-lived.

Most market analyses and market predictions assume a state-of-the-art, and within the limitations of this assumption, such predictions can be very useful. However, by superimposing a technological analysis on the purely dollar-market analysis, a much more accurate estimate of the future is possible. By the use of this particular engineering contribution to market analysis, an industrial corporation has a much more physical and realistic basis for planning.

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Military procurement is the biggest business in the Nation. It takes one fourth of our total budget. Good management of this business is essential to the nation's well being. AEROSPACE MANAGEMENT has been a leader in the criticism of procurement practices. (See Vicious Procurement Practices June 60, Sept. 60, Nov. 60, Jan. 61, May 61). Now it is time to light some candles rather than to curse the darkness.

● —— SPECIAL STAFF REPORT—PART I —— ●

How To Improve Procurement Practices

All is not well with procurement practices in the Department of Defense. And, Senator George Smathers (D-Fla.), knows it.

In May, 1961, Senator Smathers appointed a seven-man Military Procurement Advisory Committee headed by Carl G. Hokanson, President of the C. G. Hokanson Company, Los Angeles, to diagnose the ills. The advisory committee fanned out into industry, selected a group of associates, and dissected twelve major problems areas.

More than 50,000 man hours went into compiling the finished report. It represents a synthesis of the opinions of all contributors. The report cautions ". . . the conclusions and recommendations expressed herein do not necessarily, in each instance, reflect the individual views of the associates listed . . ." This indicates the issue is so touchy that even the committee could not entirely agree.

In the report, each chapter deals with a particular phase of the DOD procurement muddle. The chapters are split into three distinct sections: COMMITTEE INQUIRY, COMMITTEE STATEMENT, and RECOMMENDATIONS. The paragraphs devoted to the COMMITTEE STATEMENT give a detailed summary of the procurement position as it exists today and a discussion of the working procedures on that particular aspect. AEROSPACE MANAGEMENT reproduces below, without alteration, the sections of the first two chapters devoted to the inquiry and the recommendations of the committee.

Data from the rest of the report will be published next month.

ADVERTISED VERSUS NEGOTIATED CONTRACTS

Committee Inquiry—There has been concern with the military's use of negotiated procurement under authority of the seventeen exceptions contained in the Armed Services Procurement Act (Title 10 USC, Section 2304) rather than the use of formal advertising. Consideration should be given as to the areas in which each of these two forms of procurement is appropriate and to the over-all impact of each type of defense procurement.

Recommendations—In light of the significant position of negotiated procurement as the most appropriate method for expenditure of the greater portion of our defense funds, it is recommended that the statute be modified to eliminate the preference for advertising over negotiation and that the ASPR be modified correspondingly to permit the military department to exercise its judgment in selecting the type of procurement which best satisfies the specific conditions for each proposed contract.

In the areas of both advertised and negotiated procurement, it is recommended that greater emphasis be placed upon all of the major procurement factors including quality, delivery and technical advances rather than the lowest bid price alone.

Military Procurement Advisory Committee members who met with Senator Smathers for the formal presentation of their final report include: Gilbert Cuneo, William McInarnnay (committee coordinator), Carl Hokanson, E. D. Carter, and Lem Anderson (committee coordinator).

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While it is the Committee's judgment that formally advertised procurements should, by statute and by regulation, have equal stature with negotiated procurements that involve some form of effective competition, the Committee believes that single or sole source procurements should be treated separately both in the statutes and regulations, and should, as a precautionary measure against misuse, continue to require justification. Title 10, Section 2304 of the United States Code dealing with this matter should be amended to delete from the seventeen exceptions those which presently apply to competitive negotiation and to include only those justifications deemed necessary when single or sole source procurement is utilized by the military departments.

The Code should be amended, furthermore, to clearly define three methods of procurement; namely, formal advertising, competitive negotiation, and single or sole source

procurement, the latter requiring careful justification. The Committee believes that if competitive negotiation were released from the requirement of justification as an exception, the tendency would be for the military departments to exact fuller explanation from Contracting Officers for single or sole source actions which should be the subject of such attention. In short, the emphasis would be placed where it belongs.

PROPRIETARY RIGHTS

Committee Inquiry—The Government, through ASPR Part 2 of Section IX, Date and Copyrights, and further, through military specifications such as MIL-D-70327 and AF-MCP 71-77, requires that its suppliers, including subcontractors, disclose data, processes, and other know-how in drawings made and delivered to the Government under the contract. This practice assumes that the Government has the right to utilize such data, processes and know-how for follow-on procurement.

The question arises as to the propriety of such a requirement by the Government and whether or not such practices tend to greatly increase the cost of defense procurement in relation to the benefits derived.

Recommendations—There is a degree of clarification afforded by the Department of Defense explanation of contractors' rights in data and the effect of these rights of specification such as MIL-D-70327. This Committee feels, however, that industry is, in general, not clear as to the degree of protection it already possesses and the Committee believes that the confusion existing in this field should be eliminated by simplifying the system under which contractors' rights are delineated. Industry can perhaps be informed of the procedures by which it can protect the rights in data it now enjoys through a vigorous educational program, which presumably would be at its own expense. There is a question whether the many small business defense suppliers can afford the expense of a staff of procurement experts to advise them of these most valuable rights.

Having accepted the fact that MIL-D-70327 acknowledges rights as prescribed by the contract, we revert to the original and basic complaint of industry; namely, that the reverse engineering clause presently in the ASPR definition of proprietary rights makes the protection means to be afforded by this section meaningless. The Committee recommends that the reverse engineering concept be eliminated from ASPR IX, Part 2 and that the following definition of proprietary information, which more closely parallels the common law of property rights and is contained in the Mutual Security Act, be adopted:

> The term 'information' means information originated by or peculiarly within the knowledge of the owner thereof and those in privity with him, which is not available to the public and is subject to protection as property under recognized legal principles.

Under research and development contracts, the Government acquires unlimited rights to use all data which are delivered under the contract; however, paragraph (i) of the clause eliminates the need for furnishing data whether proprietary or not if it pertains to a standard commercial item or service offered for sale or sold commercially by any supplier, provided the item is identified as to source and its characteristics are furnished.

It is recommended that this portion of the clause be revised to permit the contractor to withhold proprietary information which was previously developed at private expense without regard to whether or not such items were sold or offered for sale. Further, the contractor should be required to disclose only that background data which was developed under the particular contract involved.

In order to relieve the reluctance of subcontractors to furnish proprietary data to prime contrctors for ultimate delivery to the Government, provisions should be made to permit the transmission of data directly from the subcontractor to the Government without passing through the prime or higher tier subcontractor.

The Committee recognizes that there are instances where the Government has the need for and the right to acquire proprietary rights. Proprietary data which the Government seeks to acquire for necessary purposes should be the subject of negotiation, separate and apart from the negotiations regarding price of other items under the contract. The price to be paid for such data should be fair and reasonable, recognizing the true value of the data itself and not merely the cost of preparation and reproduction thereof.

DOD policy should be revised to be more receptive to the inclusion of limited rights clauses by procuring agencies in contracts where such action would be appropriate and would not be detrimental to the Government's needs.

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To make effective decisions, each management echelon needs a clear view of problems on its own tier. A realistic management-controls system helps decision makers by spotlighting problem areas while charting a project's progress.

Line-of-Balance Technique Directs Decision Making

by Dr. William Bloom,
Manager Corporate Management Controls Office
General Precision, Inc.

Dr. Bloom
. . . a clear view is a must . . .

► From the vantage point of management three vital questions need asking over and over: What is our goal? What problems are we facing? How are we doing?

The accuracy with which these questions are answered will control the course of the program involved.

Only a clear view from "the top" can evoke clear management decisions. This view must give top management concise data that reflect program status, free of unessential details. Also, it must provide ready identification of the current or anticipated problem areas for timely decision making.

Through its management controls office, General Precision has developed a management controls system that provides this "clear view" from the top. In addition, it offers a clear picture of the program's status and problem areas relating to each level of management. Basically, the system is equally applicable whether the program is large or small, and whether it involves development, engineering or manufacturing.

In this system, data are condensed and synthesized, but not altered, during processing for successive management review and action. At each level of management the facts can be viewed and suggested corrective action passed on to the next level. Lastly, integration of available cost and performance data reflects the progress achieved in terms of expenditures.

Management Control System—Recognizing the importance of management controls in meeting delivery and cost targets, industry and government have encouraged the development of effective management techniques. As a result, during the past decade, new and improved tools have been developed, such as Pert, Critical Path, Line of Balance and Milestone Reporting.

Primary function of General Precision's management controls office is to provide management

control information at the corporate level, and to coordinate activities within company divisions. System used incorporates certain key features from the above mentioned techniques, and others, combined to form a completely integrated tool for management's use.

One major application of this management controls system was in the Federal Aviation Agency's Data Processing Central program at Atlantic City, N. J. This case history is presented in detail in a book prepared under the sponsorship of the Bureau of Research and Development, FAA, entitled, "Managing a Development Program."

System Features—General Precisions management controls system is initiated at the proposal stage and continues until a program's conclusion. System's features include:

- Establishment and maintenance of a well-integrated set of internal controls such as task analysis, input/output analysis, manloading, critical resources, cost and inventory control. These factors permit the preparation and maintenance of highly reliable PERT networks, or Level III Line of Balance Charts.
- Development and use of techniques for controls which are external to the project such as PERT Summary Charts, or Level I and Level II Line of Balance Charts, and Deviation Reports with supporting detailed information.
- Wide use of visual displays at the operating level and in the corporate management controls center for dynamic reporting of status.
- Availability of trained personnel experienced in the principles and use of management controls.
- Regular examination of program status by the corporate management controls office to direct top management's attention toward existing and impending problem areas by briefings, written reports and visual displays in the control room.
- Development of a control system by one of the divisions of Gen. Precision Librascope Operations Control System—LOCS. When fully operable, LOCS will provide a mechanized data-collection and processing system. This will permit pertinent data to be automatically collected and entered into the system for rapid analysis and dissemination of current status reports.

How System Functions—Basically, the system evolves through a step-by-step selection, definition, measurement, interpretation, and charting of key events in a program. This system can also be used in organizing work that goes into bid proposals. It offers a realistic basis for judging a company's estimate. The same charts used in the bid proposal for a program can be updated and used later to monitor the conduct of the program.

System functions at three basic levels of management.

(1) At the top level—corporate management, or if it is a divisional program, at the divisional president's level.

(2) At the middle management —project managers.

(3) At the operating level—supervisors.

Each level monitors its own program status, anti management sigalerted, by conspicuous danger signals, to take corrective action. Charted facts are funneled up through successive management levels to the top. At each level, areas needing higher management action are so marked before passing the facts up to the next level. Thus, by the time these data reach top management, they have been merged into a three-chart Master Plan giving the "big picture."

This master plan is, in fact, the picture which answers the top management's leading questions. It may tell them, without mixing them in a maze of detail—whether:

- Delivery schedules are being met.
- Inventory levels of raw materials and parts are being managed adequately.
- Operations are progressing within budget limitations.
- There are any bottlenecks in the flow of materials, components, and parts. If so, where?

Initiating The Program — Organization of a program begins with a conference with the project manager, his senior supporting supervisors and the controller. Initial step in installing management controls is to set up ground rules. In addition, the following elements are outlined.

(1) Provision for a clear statement of project organization and responsibilities.
(2) Identification of the tasks and an inventory of their complexity and cost.
(3) Analysis of manloading and critical facilities.
(4) Comparison of input/output to insure proper integration.
(5) Provision for basic networks or flow diagrams with required man-hours, material costs and progress reports.
(6) Examination and re-evaluation of the plan to get maximum performances and to minimize cost.
(7) Rapid feedback progress and cost information, and a comparison with the program forecast.

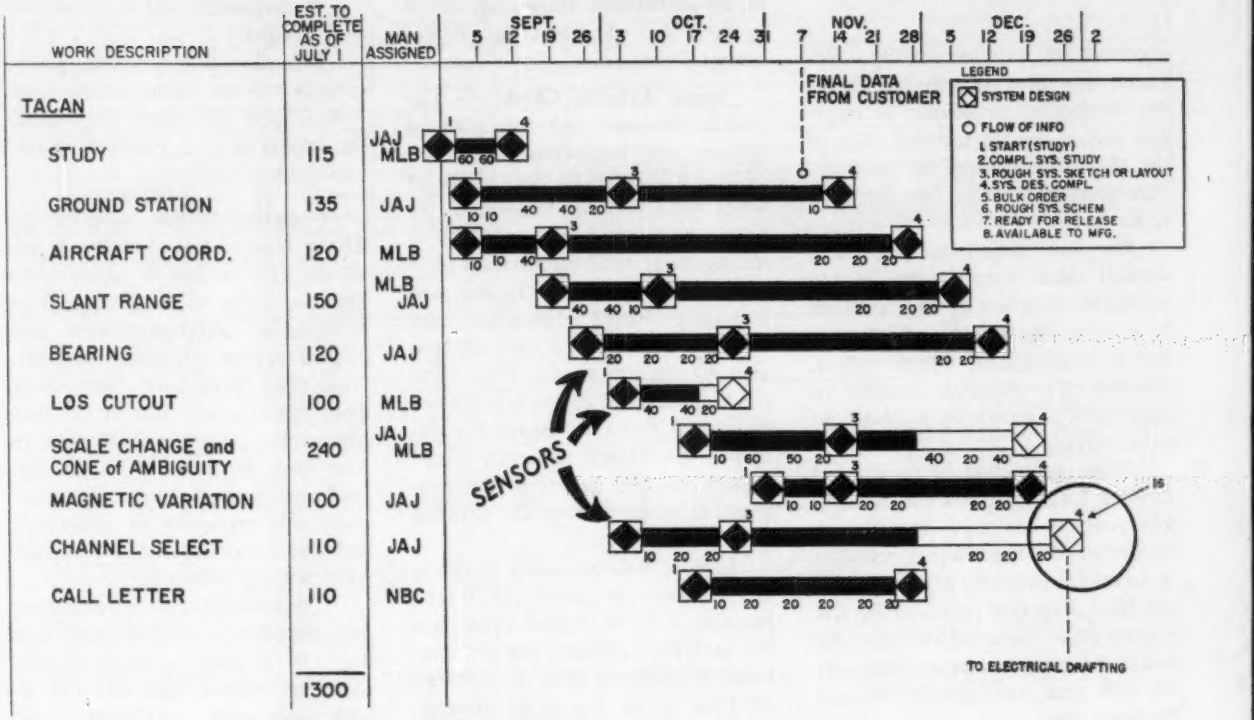
Display of Information—Facts generated within the project can be displayed by PERT Networks or Line of Balance Charts. Both employ a language of symbols and diagrams to present the basic display and its progress or revision. Both PERT networks and Line of Balance charts have been used at various levels of management controls.

A description of the internal management controls is now in order. Since the PERT technique has already been publicized widely, this description will be confined to the Line of Balance application. The basic management control principles are similar whether PERT or Line of Balance techniques are used.

Line of Balance charts come to life with descriptive symbols. These are called "sensors" (Fig. 1), and are designed to cover the entire

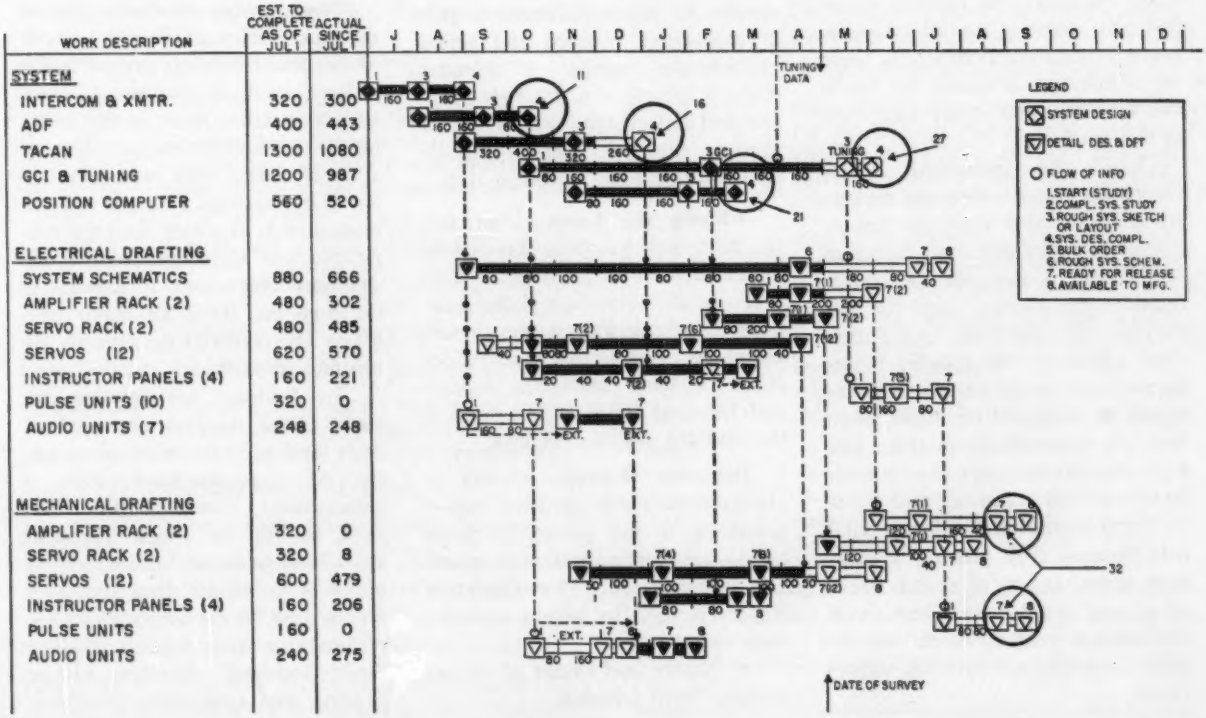
TACAN SYSTEM DESIGN

Fig. 1. Individual Flow Diagram



FLIGHT SIMULATOR-RADIO AIDS

Fig. 2. Integrated Flow Diagram


WORK DESCRIPTION
EST. TO COMPLETE AS OF JUL 1
ACTUAL SINCE JUL 1
J A S O N D J F M A M J J A S O N D
TUNING DATA
SYSTEM
INTERCOM & XMTR. 320 300
ADF 400 443
TACAN 1300 1080
GCI & TUNING 1200 987
POSITION COMPUTER 560 520
ELECTRICAL DRAFTING
SYSTEM SCHEMATICS 880 666
AMPLIFIER RACK (2) 480 302
SERVO RACK (2) 480 485
SERVOS (12) 620 570
INSTRUCTOR PANELS (4) 160 221
PULSE UNITS (10) 320 0
AUDIO UNITS (7) 248 248
MECHANICAL DRAFTING
AMPLIFIER RACK (2) 320 0
SERVO RACK (2) 320 8
SERVOS (12) 600 479
INSTRUCTOR PANELS (4) 160 206
PULSE UNITS 160 0
AUDIO UNITS 240 275
DATE OF SURVEY
LEGEND
SYSTEM DESIGN
DETAIL DES. & DFT
FLOW OF INFO
1. START (STUDY)
2. COMPL. SYS. STUDY
3. ROUGH SYS. SKETCH OR LAYOUT
4. SYS. DES. COMPL.
5. BULK ORDER
6. ROUGH SYS. SCHEM.
7. READY FOR RELEASE
8. AVAILABLE TO MFG.

spectrum of project activity. Between any two symbols are shown the number of man-hours or material dollars needed for that stage of the plan. The sum of all these figures gives the budget for the total task.

On flow diagrams, (Fig 1&2) vertical lines connect the related sub-tasks; direction of flow is shown by arrows. The transfer of information is suggested by a broken line, whereas the physical transfer of equipment is shown by a solid connecting line.

After completion of provisional Level I Charts, comes the detailed job analysis for each major task and sub-task. This step is reflected in Level III (working level) individual flow diagrams prepared by the supervisors. These charts list the tasks, the budgeted hours and cost for each task, and identify the man for each job.

Next step consists of bringing together the Level III data into one or more Level III Integrated Flow Charts. This is done by the supervising manager. The result is a unified plan showing the interplay between related components. If there are conflicting demands for facilities or time, they come into view at this stage.

Now, the Integrated Flow Charts are tested—they are reviewed in conjunction with the "input-output," manpower and facilities needs derived thus far. A simple input/output sheet is used for this purpose. On this form each supervisor tabulates the specific inputs he needs to complete the tasks assigned to him, and the dates when they are required. From these lists each supervisor notes the outputs he is expected to provide and when.

Input/output lists play a vital role because they provide a common understanding of what is needed to meet target dates. They reveal the areas of conflict which may require negotiations between supervisors.

As a result, the project manager may elect a new course of action. This information is then fed back to the supervisors for incorporation in their flow diagrams and input/output sheets.

Senior Echelon Charts — The PERT Network and the Line of Balance integrated flow charts are designed specifically for levels of supervision directly responsible for doing the work. Senior echelons of management need information on a more distilled form. To this end Summary PERT Networks and Level II and Level I Line of Balance Charts are used.

Each level of charts is a synthesis of the previous levels. For example, the PERT Summary Chart reflects the key events in the program as selected from the detailed network.

Line of Balance Level II charts are synthesis of Level III charts; likewise, a Level I chart condenses the data contained on one or more Level II displays (Fig. 3). Except for their levels, the basic elements of these Level I and II displays are the same. They include the following elements: a graphic presentation of the work plan, scaled against time, and symbolized with standard sensors of accomplishment; a plot of cumulative planned and actual expenditures against a calendar scale; a record of a program progress and budget status—both gauged against the set Line-of-Balance standard for some specified date.

Closing the Loop—Thus far, the discussion has been directed to the installation of the system. However, equally important is the feedback of concise information in sufficient detail to permit effective decision making. Deviation reports and financial status report support the updated graphic displays.

Deviation Reports—Sensors or checkpoints which are not met—according to the prescribed timetable—are automatically examined and re-evaluated. The Deviation Report is used to inform management on:

- Nature and extent of all departures from schedule.
- Why the problem exists.
- What action has been taken to solve the problem.
- Any additional corrective action needed.

Deviation Reports are geared directly to the Management Controls Charts. Therefore, they reflect the impact of each problem on cost and delivery.

Financial Status Reports—These reports are used for listing all the data needed to appraise the financial status of the project. This is done by comparing work performed against predicted performance. The data used here come from time cards and from flow charts that the supervisors used to base their estimates. Financial reports to operating personnel normally are expressed in man-hours and material dollars for comparison with original estimates.

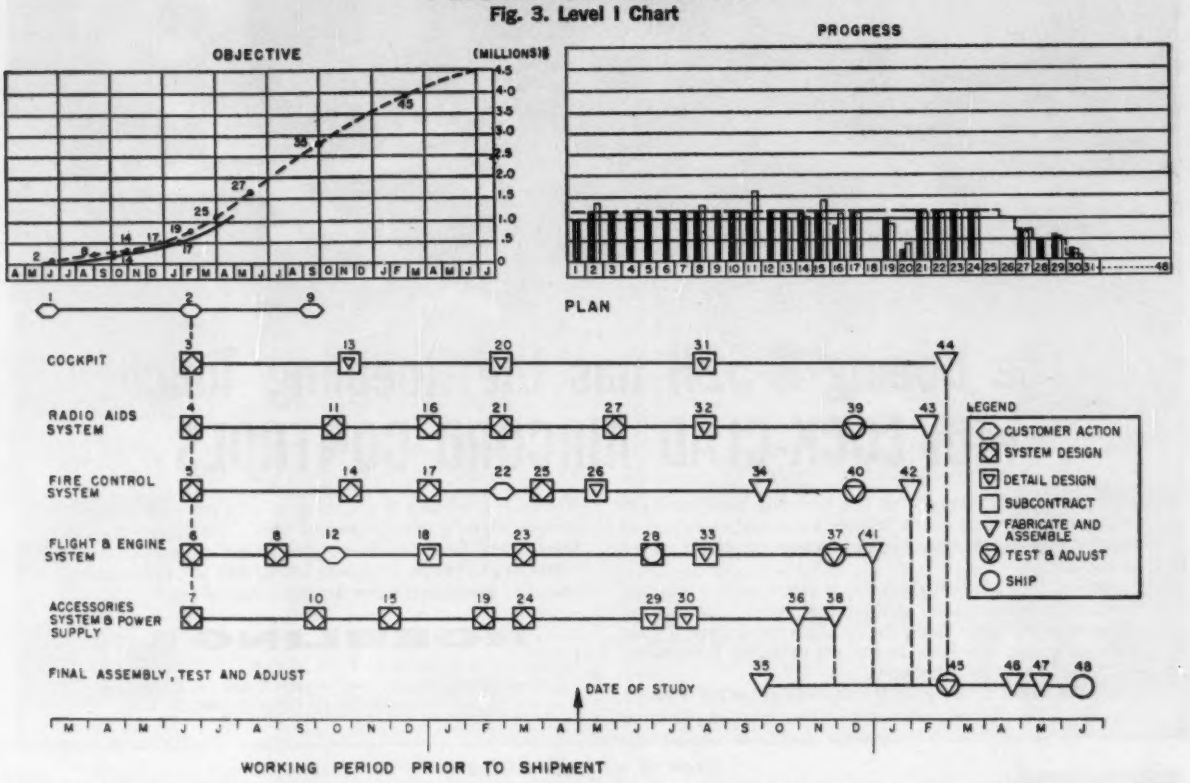
Top management is concerned with the entire picture of profit and loss. It is also concerned with changing burden-rates as well as with individual performances. Hence, financial reports to top management should contain complete cost data to allow comparison with bid or negotiated figures.

Management Review—One of the most important elements of our management controls system is the orderly review of progress. A detailed review takes place at the working level at no less intervals than on a weekly basis. This is usually followed by meetings with the division management at which time the major problem areas indicated on the summary charts are reviewed. At the corporate level, all major programs are reviewed periodically by top management.

To facilitate management review, visual displays are used at each level to indicate program status. At corporate headquarters a management controls room has been set up in which pertinent charts and summary information on major programs are displayed. This area is used for the corporate review of progress on a regular basis to direct top-level attention toward existing and impending problems.

FLIGHT SIMULATOR

Fig. 3. Level I Chart



(NOTE: This chart is normally accompanied by a sensor-identification list, omitted here, to describe all the project activity phases depicted in numbered symbols. Examples: 1—Contract award; 2—Specifications approved; 3 through 7—Start of system studies; 8—Force & moment equations complete; 9—Contract freeze date of data, etc.)

TYPICAL DEVIATION REPORT ON ITEMS NOT IN BALANCE

(Item numbers here key in with those of bar-chart above)

Item No. 2	Specifications Approved
Cost problem:	Expenditures exceeded the budget because the original specifications were not clearly defined. As a result, more manhours were required in negotiation with the customer and in preparation than were budgeted.
Item No. 8	Force and Moment Equations Complete
Comment:	Since the complete data package was revised by the customer, manhours expended exceeded the budget.
Item No. 11	ADF System Sketch Complete
Cost problem:	Several false starts because of inadequate data were responsible for expenditures exceeding the budget for this item.
Item No. 13	Stress Analysis Complete
Item No. 14	Interceptor System Sketch Complete
Comment:	The tasks were not as complicated as originally estimated resulting in expenditures below the budget.
Item No. 15	Complete Power Distribution Design
Cost problem:	Because of the tight schedule, it was necessary to overman the job to complete the task. This action resulted in excess costs over the budget.
Item No. 16	TACAN System Sketches Complete
Problem:	Only nine of the twelve system sketches for the TACAN system have been completed. Information required from the customer is still missing and is delaying the design effort.
Cost problem:	Because of inadequate data several false starts were made increasing the expenditures over the scheduled budget to date.
Action taken:	Letters have been sent and trips made to the customer's plant. Specific items of required information have been discussed and dates for availability of these items have been established.
Further Action Required:	In view of the past delays in obtaining data, management should inform the customer that the delivery will be delayed unless the information is made available by May 8. (etc.)

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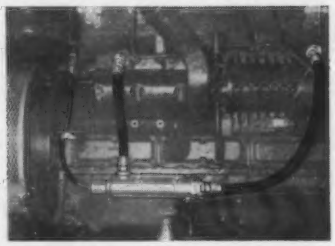

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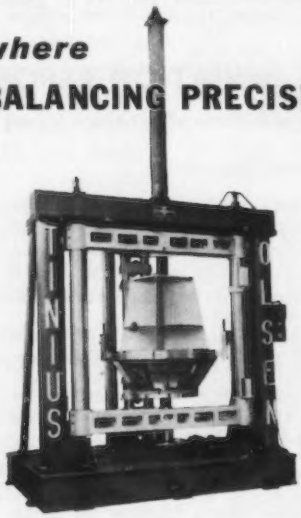

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Men on the Move

James T. Pyle
General Precision

JAMES T. PYLE, formerly deputy administrator of the Federal Aviation Agency has joined General Precision, Inc. as head of the firm's Washington, D. C. office.

W. L. WHITTIER, appointed vice president deputy general manager; J. O. MOXNESS, vice president commercial sales; LEO J. DEVLIN, vice president engineering and product development, in the Aircraft div. of Douglas Aircraft Co., Inc. R. L. JOHNSON was named vice president for product development in the Missile & Space Systems div., and J. R. ALLEN, vice president and general manager of the Tulsa div.

Ray A. Zuck
General Atronics

RAY A. ZUCK new head of Atronics' new electronic tube and instrument div. at General Atronics Corp.

John Mihalic
NMA Award

J. DONALD RAUTH has been appointed to the new post of TITAN project chief. The vice president of Martin's Nuclear Div. will handle activation of the near-operational TITAN I and production and testing of the advanced TITAN II.

JOHN MIHALIC, vice president of Avco Corporation, was recently awarded the National Management Association's "Management Man of the Year" award at the NMA convention in Chicago.

Harold L. Flowers
Avco

HAROLD L. FLOWERS, former director of weapon systems for Goodyear Aircraft Corp., is the new general manager of engineering at Avco Electronics and Ordnance Div.

JOHN H. BEEDLE has joined EPSCO, Inc. as executive vice president and general manager with responsibility for the product-based divisions of the company. ROBERT G. CLARK is newly elected president of International Resources Corp., an EPSCO subsidiary.

Dr. Theodore H.
Maiman
Quantatron, Inc.

S. E. WEAVER has been appointed vice president of engineering and marketing at Marquardt Corp.

DR. THEODORE H. MAIMAN has been elected a vice president of Quantatron, Inc.

DR. AIMISON JONNARD has been appointed vice president in charge of planning at Celanese Chemical Co.

E. W. RAWLINGS was recently named president of General Mills. He succeeded C. H. Bell, who has served as president since 1952.

GAYLORD W. NEWTON has been appointed consulting specialist in the marketing of General Electric's large jet engines.

A. WILLIAM CHRISTOPHER, JR. of Sylvania Electric Products, Inc., appointed regional vice president of the Armed Forces Communications and Electronics Assn.

RAYMOND TRAPP was recently appointed general sales manager for the Bendix Products Aerospace Div.

THOMAS W. GOODWIN newly elected vice president of Gorham Corp. He will coordinate corporate programs for plants and equipment.

GEORGE E. GEYER named director of engineering sales of Bulova Research and Development Laboratories.

DR. PETER L. NICHOLS, JR., former Director of the space sciences and propulsion div. of Stanford Research Institute, is the new senior scientist at Aerojet-General's solid rocket plant in Sacramento, Calif.

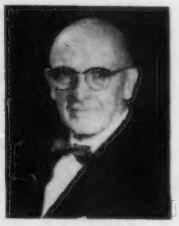
JAMES F. HEALEY has become vice president of Minneapolis-Honeywell's Aeronautical Div.

LT. GENERAL JAMES FERGUSON is newly appointed deputy chief of staff for research and technology. He was formerly vice commander of the Air Force Systems Command.

R. L. BOORMAN was recently appointed to the newly created position of director, corporate planning and control for Kaiser Steel Corp.

STEPHEN T. HERR has been appointed executive vice president and general manager of United Electric Controls Co.

Dr. Aimison Jonnard
Celanese Chemical



Thomas W. Goodwin
Gorham Corp.

George E. Geyer
Bulova Labs

James F. Healey
Minneapolis-Honeywell

Stephen T. Herr
United Electric
Controls

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Matthews Airgrit eliminates many marking problems. It may be the answer to yours.

Through inexpensive molded rubber masks, it will "blast-etch" trademarks, names or codes with lettering as small as .055" within a fraction of a second. Masks have surprisingly long life for economical marking.

Self contained unit needs only air source and electrical outlet for easy installation. Simple to operate, no special training required.

Write for Bulletins C-25, C-26 or forward part for sample marking

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JAS. H. MATTHEWS & CO.

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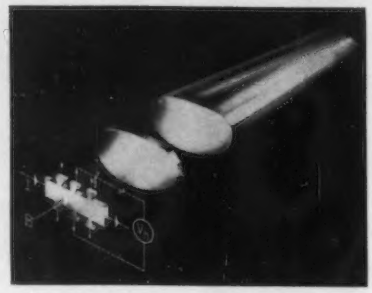
Circle 14 on Inquiry Card

NEW Materials

Indium Antimonide

Single crystal Indium Antimonide is being produced in commercial



quantities. A compound semiconductor of the III-V family, it is suited for use in high mobility devices.—*Micro State Electronics Corp.*

Circle 100 on Inquiry Card for more data

Conformable Coatings

One component dip coatings for electrical components and metal hardware are being offered. Coatings are built up over plastics, ceramic and metal parts by dipping to establish thicknesses up to 1/32 in. When baked at 300° F, coatings are converted into semi-rigid material with good adhesion and thermal shock resistance.—*Furane Plastics Inc.*

Circle 101 on Inquiry Card for more data

Silicone Rubber Foam

Low density, silicone rubber foam can be handled immediately after

completion of the reaction. Producer claims Silastic RTV S-5370 is heat resistant and resilient. Foam is formed in five minutes at room temp.—*Dow Corning Corp.*

Circle 102 on Inquiry Card for more data

Pyrolytic Graphite

Components are being produced of pyrolytic graphite, a thermally ab-

sorptive material that will withstand temp in the 4000° to 6000° F range. The higher the temp, the stronger it becomes. Material is recommended for rocket nozzles, nose cones, heat barriers and nuclear applications. — *Beryllium Corp.*

Circle 103 on Inquiry Card for more data

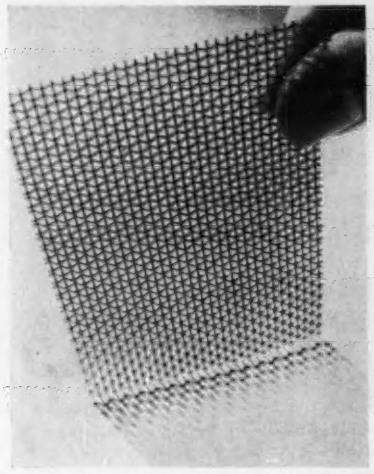
Copper-Clad Laminate

Copper-clad laminate for printed circuitry is said to meet specs for room temp peel and have a hot peel strength of 2 to 4 lb/in. of width, at 500° F. Grade G-10R is available in sheets of 36 x 36 in. and 36 x 48 in. with usual copper foil thicknesses.— *Synthane Corp.*

Circle 104 on Inquiry Card for more data

Stainless Wire Cloth

Wire cloth woven of high-temp stainless steel alloy is said to have properties comparable to more highly



alloyed and exotic materials in the 600° to 1000° F range. Parts made of NS-A286 wire cloth can be hardened after forming.—*Reynolds Div., National-Standard Co.*

Circle 105 on Inquiry Card for more data

Thermoplastic Resin

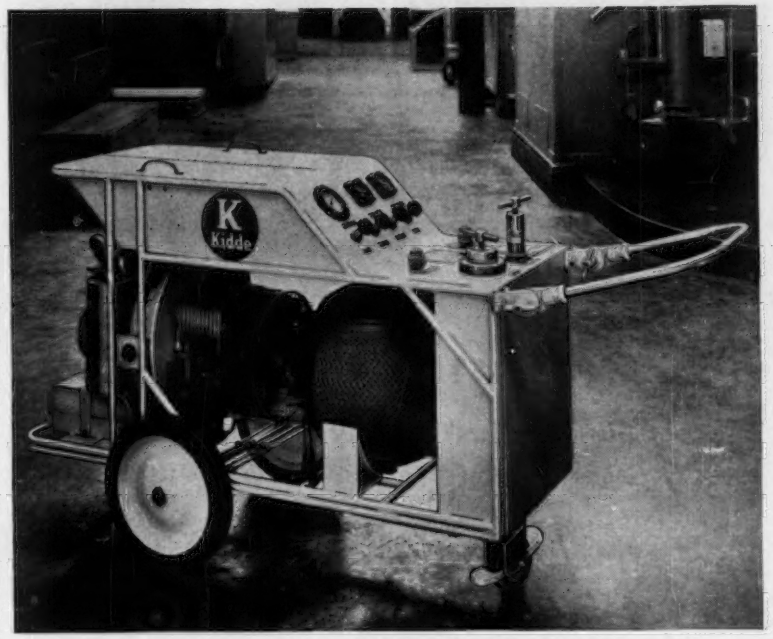
Flourocarbon plastic is available in an extrusion grade, and injection and comparison molding grade, and a plasticized grade for applications requiring a high degree of flexibility. Material has good thermal stability and chemical inertness. Chlorine added increases mechanical properties and moldability. — *Minnesota Mining & Mfg. Co.*

Circle 106 on Inquiry Card for more data

Mylar Polyester Film

Line of heavy gauge Mylar film has been extended to include thick-

New Kidde 5000 psi pneumatic system features mobility, precision regulation!



From the laboratories of Walter Kidde & Company, Inc., comes this mobile pneumatic system which delivers 4 cfm of clean, dry air at pressures up to 5000 psi. Completely portable and easy to maneuver, the system features two highly accurate regulators: one for pressure ranges of 0-200 psi; the other for pressures up to 5000 psi. All controls and gauges have been placed at the optimum level for accessibility and ease of handling. Light in weight, the system measures 22″ by 49″ by 32″, and is available powered with either electric or hydraulic motors or gasoline engine.

Used for aircraft and missile ground-support equipment and for laboratory applications, systems of this type can supply high and low-pressure air in ambient temperatures varying from —40 degrees to +120 degrees F. For more information, write Kidde today.

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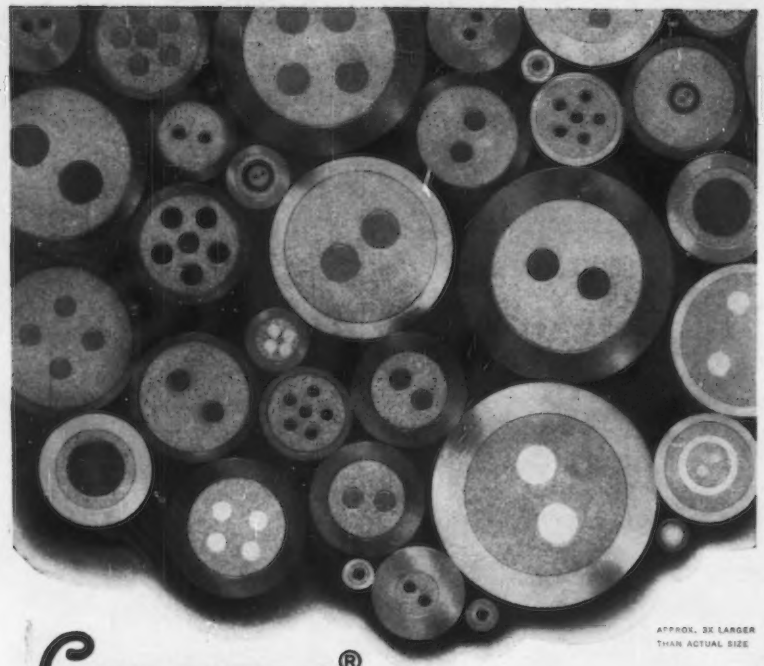
Walter Kidde-Pacific, Van Nuys, California • Walter Kidde & Company of Canada Ltd., Montreal, Toronto, Vancouver



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"Button-Box" Variety to fit every temperature measuring need

Like the button-box every woman keeps handy, Ceramo* Thermocouple wires offer you virtually unlimited selection to fit almost any temperature measuring application. For instance:

Lengths – 1/2″ to 30 ft. – to 80 ft. on special order!

Diameters – 1/32″ to 7/16″, small sizes give fast response – large sizes provide longer life.

Coaxial Construction – 1, 2, or 3 metal sheaths, with or without interposed insulation, provide extra protection – allow special electrical circuitry.

Insulations – Magnesium, Aluminum, Zirconium, Beryllium oxides.

Conductors – 1, 2, 4 or 6 conductors available in all ISA standard materials, plus several combinations of Platinum-Rhodium, or Tungsten-Rhenium, and Iridium-Rhodium . . . measure temperatures from –450°F to plus 4000°F.

Sheath Materials – Stainless Steels, Inconel, Aluminum, Copper, Nickel, Nichrome V, Titanium, Tantalum, Platinum 10% or 20%, Rhodium, Chromel, Alumel, Hastelloy, Monel, or any workable material.

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NEW Materials

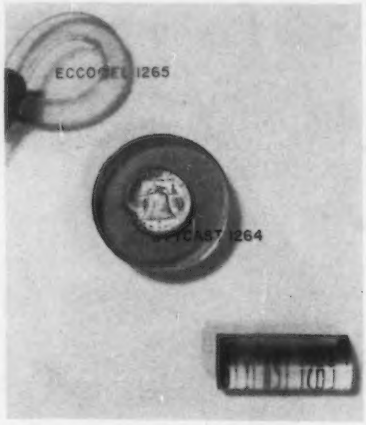
continued

nesses from one-quarter mil to 14 mils. 1400 gauge (14 mil) film was added to provide a heavier, more rigid material for insulation and materials surfacing applications.—*E. I. Du Pont de Nemours & Co.*

Circle 107 on Inquiry Card for more data

Transparent Epoxy Resins

Line of clear epoxy resins includes Stycast 1263, 1264 and Eccogel 1265. 1263 is rigid, 1264 is flexible and 1265 is a firm gel. Continuous use



temp for 1263 is 400° F, for the others it is 300° F.—*Emerson & Cuming, Inc.*

Circle 108 on Inquiry Card for more data

Sintered Molybdenum

Sintered molybdenum mill products have been added to line of refractory metal products. Company also produces arc-cast molybdenum. —*Refractomet Div., Universal-Cyclops Steel Corp.*

Circle 109 on Inquiry Card for more data

Hi Temp Paper

Quartz fiber paper is said to be capable of withstanding 3000° F. Paper can also be used with cryogenic products in temp down to —459° F. Paper can be impregnated with phenolic resin for ablation and heat shielding applications.—*C. H. Dexter & Sons, Inc.*

Circle 110 on Inquiry Card for more data

NEW Worth Asking For LITERATURE

Preparation for Lunar Flight

Present progress on the ultimate requirements for effecting a lunar landing and return are described in this 21-page booklet. A full description of the spacecraft, propulsion approaches and discussions of other aspects necessary for a successful lunar mission are included.—*Thiokol*

Circle 111 on Inquiry Card for more data

Structural Parts Lab Report

Literature describes first structural parts to be developed in response to DOD call for non-brittle 300,000 psi fastener materials. — *Standard Pressed Steel Co.*

Circle 112 on Inquiry Card for more data

Pocket Component Catalogue

Pocket-sized publication features schematic diagrams and specifications of electronic and electro-mechanical components. Prices and application suggestions also included. — *Siamco, Div. of Tech-Ohm Electronics, Inc.*

Circle 113 on Inquiry Card for more data

Advances in Hi-Vacuum

A monthly publication dealing with all aspects of vacuum systems, their development and uses.—*Scientific Engineering Laboratories, Inc.*

Circle 114 on Inquiry Card for more data

Technical Info on Compounds

Bulletins contain properties, performance charts and graphs on Fluorosilicone fluids, greases and compounds. Suggested applications for these materials are also included.—*Dow Corning Corp.*

Circle 115 on Inquiry Card for more data

Pocketsize Math. Handbook

General arithmetical rules and formulas are included along with business formulas such as profit and loss, markup, discount, simple and compound interest tables. Also contained in the 64-page publication are powers, roots, circular arc tables and other helpful aids.—*Curta Company*

Circle 116 on Inquiry Card for more data

Control System Test Set

Brochure containing performance data on semi-automatic equipment used in checkout of fire control system and for testing production line final integrated system. — *Kearfott*

Circle 117 on Inquiry Card for more data

Detecting the Future Scientist

This booklet outlines characteristics of youth which indicate a future scientist or engineer. It suggests academic and non-academic activities which will foster such a vocation.—*Battelle Memorial Institute.*

Circle 119 on Inquiry Card for more data

X-Ray Analysis Inspection

Detailed procedures of radiographic inspection for examining electrical cable terminations and splices by use of x-ray.—*Balteau Electric*

Circle 120 on Inquiry Card for more data

Design of Test Facilities

Manual offers information useful in designing and applying automated test facilities for cables, components and completed assembies.—*Associated Research, Inc.*

Circle 121 on Inquiry Card for more data

Saturn Rocket Engines

The capabilities of current Saturn launching rockets and overall expectations of the progressive Saturn missions are described in this brochure. Future rocket engine developments are also outlined.—*Rocketdyne*

Circle 122 on Inquiry Card for more data

Major Space Technology Labs

Brief description and detailed illustration of major facilities in place or under construction at General Electric Valley Forge Space Technology Center.—*General Electric.*

Circle 123 on Inquiry Card for more data

TV Eyes in Airline Terminals

How airline terminals use closed circuit television to solve communications problems is described in this publication. Ramp actvity, weather briefing and display of arrival/departure schedules are a few applications outlined.—*General Precision*

Circle 124 on Inquiry Card for more data

Industrial Gas Data

A smartly bound 48-page, pocket-sized booklet lists physical and chemical properties of gases. Also contains conversion tables to change volumetric information on gases from one equivalent measure to another.—*Airco*

Circle 125 on Inquiry Card for more data

Subfreon Research Facility

Publication covers the broad areas of the physics and engineering process through which subfreon temperatures are attained and made usable at Arthur D. Little Cryogenics research facilities.—*Arthur D. Little*

Circle 126 on Inquiry Card for more data

How to Sell to McDonnell

This guide is provided to help prospective new suppliers in contacting McDonnell Aircraft Corp. buying and technical staffs. A map of the firm's facilities and nearby accommodations is included. — *McDonnell Aircraft Corp.*

Circle 127 on Inquiry Card for more data

Developments In Flight

A pictorial review, the second in a series, describing the contributions of General Precision, Inc., to the research and development of manned aircraft and all related control and support systems.—*General Precision*

Circle 128 on Inquiry Card for more data

Instrument Repair Facilities

Outlined are facilities reportedly used by more than 200 commercial firms, 60 of whom are said to be major military contractors. — *Cook Electric Company.*

Circle 129 on Inquiry Card for more data

7,000 Years of Solid Propellants

Forty pages of two color illustrations and text provide a history of solid propellent rocket engines to their present state of development.—*Thiokol Chemical Corp.*

Circle 130 on Inquiry Card for more data

Where to Use Lubricants

New application chart simplifies selection of proper lubricants. Chart lists forms of application. carriers for particular lubricants, typical uses and method of application.—*J. A. Postell*

Circle 131 on Inquiry Card for more data

Locating the Clouds

A report concerning the method used to determine where the cloud pictures taken by TIROS satellites are located in relation to the earth.—*Bendix Corporation*

Circle 132 on Inquiry Card for more data

Eye Protection in Your Plant

Booklet gives latest information on the establishment of a workable eye protection program. — *Fendall Company.*

Circle 133 on Inquiry Card for more data

How to Fly on Water

The progress of hydrofoil developments in the United States and what to expect in the near future is reported in this publication.—*Gruman Aircraft Engineering Corp.*

Circle 134 on Inquiry Card for more data

NEW Parts and Components

Fused Quartz for Tubing

Expected to have major significance in defense and space industries which rely on fused quartz for critical applications. Quartz is now made from silicon dioxide, a domestically available raw material. Tests have shown the new material will deform at less than one-half the rate of former quartz when subjected to temperatures of 1200°C and higher.—*General Electric.*

Circle 135 on Inquiry Card for more data

Thrust Chamber

This ablative-cooled assembly for liquid fueled rocket engines is reportedly capable of withstanding accumulated firing durations up to 7.2 min. The filament-wound chamber is said to be suited for space applications because of its high thrust-to-weight ratio and firing duration capability. —*United Technology Corp.*

Circle 136 on Inquiry Card for more data

Simulator Air Bearings

Spheres which float on a film of air to simulate the weightless and frictionless conditions of outer space are available for satellite simulators. They consist of bearings and matched seats or sockets. The socket has a number of air vents which provide sufficient air pressure for support of the bearings.—*Industrial Tectonics, Inc.*

Circle 137 on Inquiry Card for more data

Maneuverable Antenna

Part of a system expected to provide better communications with satellites. This microwave airborne antenna system includes both orientation equipment and extreme range capability. The system design employs a 10 kw, cw-power transmitter at X-band and a helium cooled maser receiver. The antenna has three axes and a beam width of 5°.—*Boeing Co.*

Circle 138 on Inquiry Card for more data

Thunderstick Rocket

A six foot long terrestrial missile. Its weight is comparable to that of a small arms weapon. It is designed for combat of armored vehicles and supersonic aircraft. The propellant mass ratio of the system is 0.99 and over. Over 99 per cent of the system weight is propellant.—*American Rocket Co.*

Circle 139 on Inquiry Card for more data

Control Rocket

This pulse modulated bipropellant rocket was developed for vernier attitude corrections of space vehicles with a pulse modulated thrust level of one pound. The N^2O^4 and N^2H^4 bipropellant is spontaneously combustible upon contact with the oxidizer. No external ignition device is required.—*Vickers, Inc.*

Circle 140 on Inquiry Card for more data

Image Converter Camera

A diagnostic tool for instrumentation of high speed luminous transient events encountered in plasma physics, chemical kinetics, hypervelocity experiments and other high speed light events. It is reportedly capable of taking framed photographs at exposure times varying from 3 to 200 millimicroseconds.—*Space Technology Laboratories, Inc.*

Circle 141 on Inquiry Card for more data

New Battery for Space

Non-magnetic sealed silver-cadmium cells, currently in use in the Explorer XII satellite, are expected to resolve space and weight limitations of nickel-cadmium batteries. These cells are said to operate at considerably higher charging rates and greater depths of discharge than was previously practicable in solar energy converter-battery power systems.—*Yardney Electric Corp.*

Circle 142 on Inquiry Card for more data

Provides Attitude Data

A light weight pyrotechnic free gyro provides roll, pitch and yaw attitude data for short range missiles. It can also be used for stabilizing longer range missiles during early periods of flight. The instrument reportedly features a 100 millisecond runup, low drift rate, electrical uncage and small size.—*Giannini Controls Corp.*

Circle 143 on Inquiry Card for more data

Measures Man's Responses

A miniaturized instrumentation packet for measuring a man's physiological responses to space flight stresses. The half-pound, transistorized packet makes 12 measurements. It is strapped to pilot's waist with sensors leading to his chest, back, arms, legs and feet. It is being used with X-15 edge-of-space aircraft tests. —*Hughes Aircraft Co.*

Circle 144 on Inquiry Card for more data

Starts Jet Engines

Designed especially for using available plant air sources, system provides up to 310 lb/min of air at 61 psig with an adjustable pressure-rise rate of four to six sec. This capacity, fully controlled at all settings, gives starter flexibility to handle a variety of jet engines. It has been used for starting J-79 engines in Vigilante attack bomber.—*North American Aviation.*

Circle 145 on Inquiry Card for more data

NEW Electronic Products

Space Powerpack

A nuclear thermoelectric power system for space, moon and other uses requiring long-lived, operation.

Uses the spontaneous decay of a radioisotope to produce heat which is converted into electricity by thermoelectric principles. The curved shields are waste heat radiators. Heat is transferred by a liquid metal. System will produce 50 to 60 kw for three months' life on the moon.—*Westinghouse Aerospace Department.*

Circle 146 on Inquiry Card for more data

2500 Channel Repeater

This coaxial cable communications repeater is less than six inches long and one inch thick yet utilizes a voice band width capacity of 2500 channels. The device amplifies signals in both directions. It has a total bandpass of 20 megs, dividable for handling 10 megs in either direction.—*Philco.*

Circle 147 on Inquiry Card for more data

TV Monitor Dark Adapted

For missile surveillance, a transistorized closed-circuit television system. Its applications are also said to include keeping watch over security installations, use on aircraft and submarines and for satellite tracking. The system comprises the camera with an image orthicon tube and 35 mm lens, a camera-control unit, and several monitoring units.—*Bendix Corp.*

Circle 148 on Inquiry Card for more data

High Capacity EDP System

Handles magnetic tape with a nine-fold increase in speed. System has a core memory unit with twice the capacity of its predecessor. The advanced 301 system permits use of over 12 tape stations. Information rate of new tape unit is 66,000 characters per second.—*RCA.*

Circle 149 on Inquiry Card for more data

Aids Saturn Flights

A retractable-probe-type angle of attack transducer in the control system of the Saturn space vehicle serves as an electromechanical aid in determining the vehicle's angle-of-attack. The angle-of-attack is determined by measuring the differential of the air pressure acting through two narrow longitudinal slots on the probe.—*U.S. Science Corp.*

Circle 150 on Inquiry Card for more data

Tests Memory Systems

Called the Memory System Exerciser, the high speed digital computer simulator evaluates complete memory systems in laboratory analysis and production testing. Of modular construction, the unit simulates exact computer environment. Simulator operates with address to address cycle times, continuously variable from 100 to 3 microseconds. Random access memories or serial buffers with address capacities to 16,384 words and word lengths to 48 bits are accommodated.—*Kese Engineering, Inc.*

Circle 151 on Inquiry Card for more data

Rocket Oriented TV

A closed circuit television system providing a vertical design geared especially for viewing long, narrow

images. The new system will reportedly enable personnel at a missile range a larger, more detailed picture of the missile as it goes through countdown activities and launching. —*General Electric.*

Circle 152 on Inquiry Card for more data

Reconnaissance Receiver

This wideband high intercept probability device will reportedly identify multiple radio and radar signal frequencies in critical space communications and electronic warfare bandwidths (500 to 12,000 mcs) without tuning. The device is intended for use in reconnaissance satellites, airborne and expendable jamming ground electronic warfare systems and laboratory RFI uses.—*Hallicrafters.*

Circle 153 on Inquiry Card for more data

"MADDAM" Computer

A fully miniaturized, practical working electronic computer designed to demonstrate the Macro-Module sys-

tem of constructing computers. MADDAM is a 16-integrator serial computer capable of providing solutions to integral-differential class equations. It is said to be the digital equivalent of an analog computer.—*Burroughs Corp.*

Circle 154 on Inquiry Card for more data

Nuclear Amplifier

Transistorized, non-overloading linear amplifier expands small pulses from nuclear detectors. Circuit design permits conversion to battery operation. Amplifyer has maximum gain of X1000. A transistorized preamp is available for use with this equipment. —*Lockheed-Georgia Co.*

Circle 155 on Inquiry Card for more data

Computer for Training

The military digital trainer, a desk-size binary computer designed for training in computer maintenance, design and programming. The device contains all elements found in larger computers. This feature is said to facilitate changeover to full scale computer operations.—*Univac.*

Circle 156 on Inquiry Card for more data

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Circle 17 on Inquiry Card

NEW Production Equipment

Power Controller

Controls high and rapid rising temperatures on test specimens within 10° in a range from room temperature to 6000° F. Designed to operate in conjunction with any standard universal testing machine.—*Marquardt.*

Circle 157 on Inquiry Card for more data

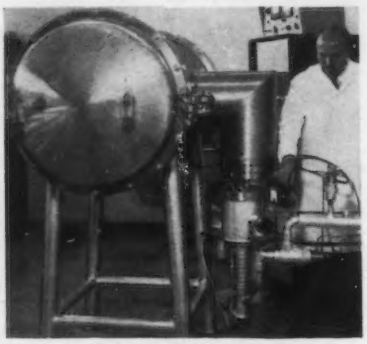
Humidity Measuring Device

Infrared Hygrometer for measuring humidity consists of a radiation source, optical filters for isolating selected wavelengths of radiant energy, a sensing tube, detector, servo balancing system and a method of zero referencing. A glass wedge is intended to compensate for the absorption of the light beam due to water vapor. The position of the wedge is an index of amount of vapor in the path.—*Electronics Group, General Mills, Inc.*

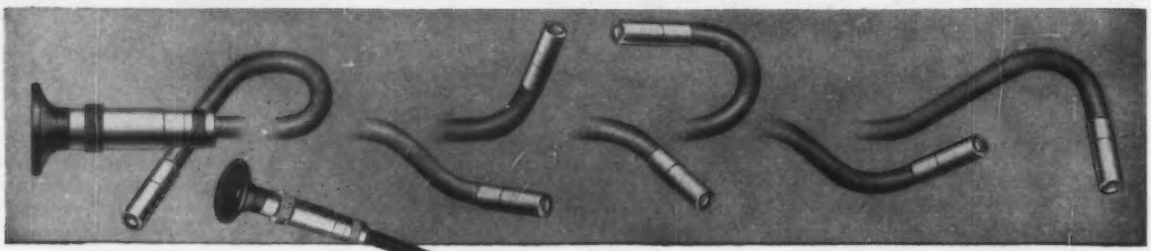
Circle 158 on Inquiry Card for more data

Ultrahigh Vacuum System

A pressure as low as 1 by 10^{-10} mm Hg range can be obtained and maintained over a period of several days



without the use of liquid helium. Applications of the new system include space simulation, vapor deposition and materials research. Among its me-



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FOR visualization in inaccessible curved areas where a flexible instrument capable of adapting itself to irregular contours is required.

Fiber Optic Borescopes are equipped with focusing eyepiece and fixed or movable objective as required. Illumination can be provided by a flexible fiber optic light carrier with an external light source or an annular fiber optic light carrier attached to the image carrier. Fiber optic light carriers are particularly advantageous for transmission of intense cold light to inaccessible or hazardous areas.

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chanical features are completely interlocked controls to protect the system from power failure, water failure and faulty startup.—*Ilikon Corp.*

Circle 159 on Inquiry Card for more data

Mixing by Remote Control

Mechanical hands operate this vertical mixer and reportedly minimize hazards involved in mixing radioac-

tive, toxic or explosive materials. Mixer shown is a ¼ pt. to one qt. model. A 5-gal mixer is in production and one of 30 to 80 cc capacity is under development.—*Atlantic Research.*

Circle 160 on Inquiry Card for more data

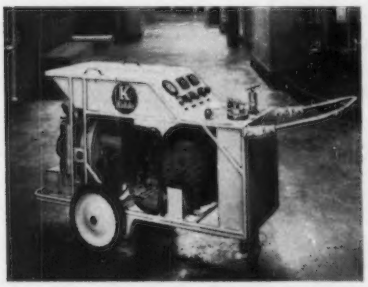
Compact Steam Generator

Designed to produce 150,000 lbs per hour steam, this generator is 4 ft high and 3 ft in diameter. Currently being used as an essential component in system for sub-cooling liquid hydrogen. Operates on hydrogen peroxide, gaseous hydrogen and water. In combination with certain other equipment, the generator reportedly makes it possible to pull extremely high vacuums with speed and controlled accuracy.—*Thiokol Chemical Corp.*

Circle 161 on Inquiry Card for more data

Mobile Pneumatic System

Supplies 4 cfm of dry, clean air at up to 5000 psi. Wheeled and center balanced, the assembly features two



air pressure regulators, each with its own outlet fitted with a quick-disconnect coupling. One used for low pressure ranges (0-200 psi) and the other for higher ranges. Powered by gasoline engine, the unit comes equipped with 20 feet of hose.—*Kidde Aero-Space Div., Walter Kidde & Co., Inc.*

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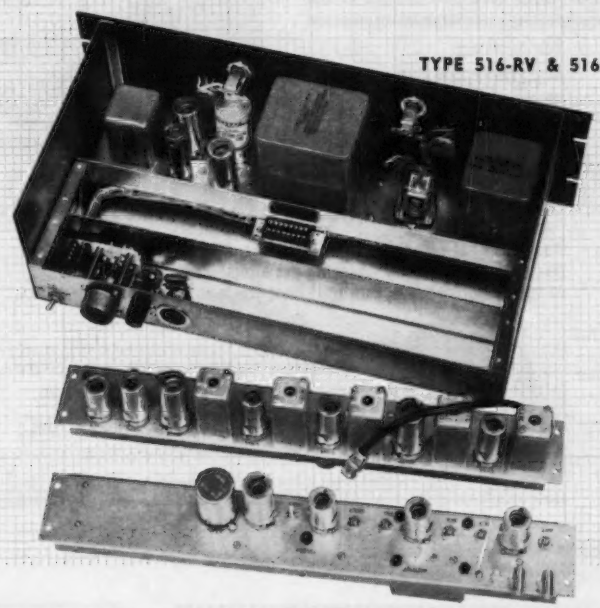
UNIVERSAL TYPE CERTIFIED COMMUNICATIONS RECEIVER

FOR COMMUNICATING WITH AIRCRAFT

TYPE 516-RV & 516-RU



Featuring two rapid "plug-in" RF converter strips for operation in frequency range 108 to 152 mc or in UHF 225 to 400 mc.

FREQUENCY RANGE — Any frequency between 108 and 152 Mcs. or 225 and 400 Mcs.

A.V.C. — Amplified and delayed A.V.C. circuit to hold the audio output constant within 3 db from 5 microvolts to .2 volt.

FREQUENCY STABILITY — Overall .002% from —10°C to 60°C ambient temperature.

SELECTIVITY — The VHF and UHF versions have a bandwidth of 36 KC minimum for 6 db and not more than 108 KC for 60 db attenuation.

SENSITIVITY — At the maximum setting of the R.F. gain control, a 1 to 2 microvolt 30% amplitude modulated signal will produce at least 500 milliwatts of audio output with at least a 10 db signal to noise plus noise ratio.

SPURIOUS RESPONSE — at least 80 db down.

OUTPUT — The audio output is one watt into either 600 ohms or 8 ohms.

INTERMEDIATE FREQUENCIES — 18.3 Mcs. and 1.85 Mcs. for VHF. 47 to 73 Mcs. tunable I.F. ahead of standard I.F. for UHF.

Technical Bulletin 516-RV-RU available on request

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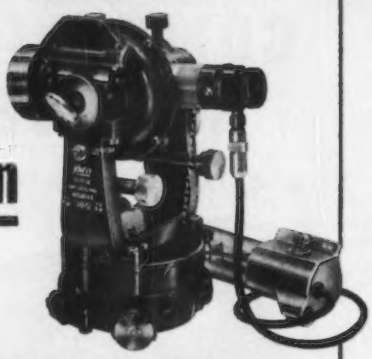

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For more information, write for Bulletin 59-SC. Address Bellows-Valvair, Hydraulics Division, Salem, Ohio, Dept. AMM-1261.

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Division of IBEC SALEM 9, OHIO

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A

Airetool Manufacturing Co. 8
American Bosch Arma Corp. 6
American Cystoscope Makers, Inc.... 70

B

Bellows-Valvair 72
Bendix Corp. Aerospace Div. 1
Boeing Company-Wichita 29

C

Classified Advertisement 72

E

Erco Radio Laboratories, Inc. 71

F

Fidelity Personnel of Phila. 72

G

Graphic Systems 70

J

Janitrol Div. Midland-Ross Corp. 5

K

Kern Instruments, Inc. 72
Kidde & Co., Inc., Walter 65
Kim Hotstart Mfg. Co. 62

L

Lindberg Engineering Co. 37
Lockheed Corp.-California 14

Mc

McDonnell Aircraft .....2nd Cover

M

Matthews & Co., Jas. H. 64

O

Olsen, Tinius 62

P

Protective Closures Co., Inc....3rd Cover

R

Raybestos-Manhattan, Inc. 12
Roebling's Sons Div., John A. 62

T

Taylor Fibre Co. 4
Thermo Electric Co., Inc. 66
Transue & Williams Co.....Back Cover

W

Wyman Gordon Co. 49

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19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126
127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162
163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198
199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234
235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252
253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288
289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306

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B. Type of Plant or Facility

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....4. Mechanical Systems & Parts
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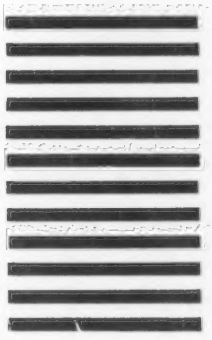

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19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126
127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162
163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198
199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234
235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252
253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270
271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288
289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306

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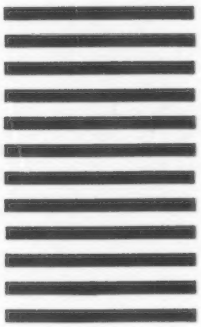

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37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
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145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162
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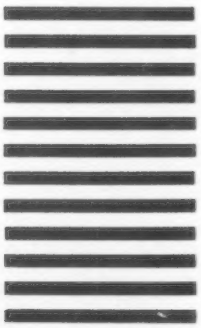

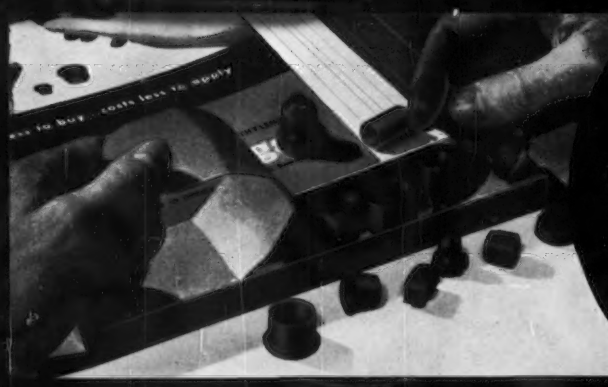

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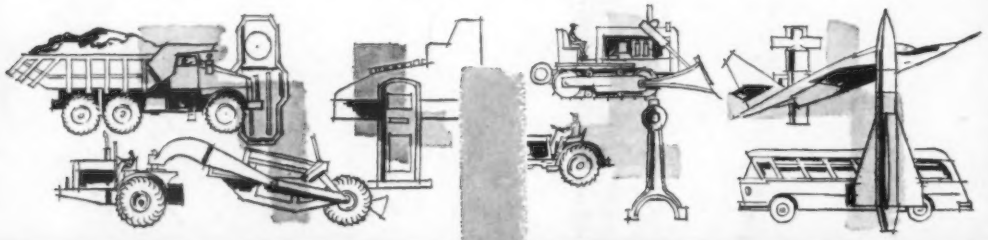

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